PLANNING FOR SOLID WASTE MANAGEMENT OF MUZAFFARPUR CITY BIHAR

A DISSERTATION

Submitted in partial fulfillment of the requirements for the award of the degree of

MASTER OF URBAN AND RURAL PLANNING

By

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JUNE, 2009

CERTIFICATE

Certified that this report entitled **"Planning For Solid Waste Management of Muzaffarpur City, Bihar"** which has been submitted by **Mr. Ashok Anand** , in partial fulfillment of requirements for the award of Post Graduate Degree of the **Master of Urban And Rural Planning,** submitted to the **Department of Architecture And Planning, Indian Institute of Technology-Roorkee, Roorkee**, is the student's own work carried out by him under our supervision and guidance.

The matter embodied in this dissertation has not been submitted by him for the award of any other degree of this or any other Institute.

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CANDIDATE'S DECLARATION

I hereby declare that the work , which is presented by me in the dissertation entitled **"Planning For Solid Waste Management of Muzaffarpur City, Bihar"**, in partial fulfillment of the requirements for the award of the degree of **Master In Urban and Rural Planning** submitted to the **Department of Architecture and Planning, Indian Institute of Technology-Roorkee, Roorkee,** is an authentic record of my own work carried out during the period from July 2008 to June 2009 under the supervision of **Prof. R.K. Jain & Dr.Ashutosh Joshi, Department of Architecture and planning, Indian Institute of Technology-Roorkee, Roorkee-247667, Uttarakhand, India.**

The matter embodied in this dissertation has not been submitted by me for the award of any other degree of this or any other Institute.

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Ashok Anand

ABSTRACT

In Muzaffarpur city the collection, transportation and disposal of solid wastes (which are highly visible and important municipal services) are unscientific and chaotic. Uncontrolled dumping of wastes on the outskirts of the city has created overflowing landfills that are not possible to reclaim because of the haphazard manner of dumping. It has created serious environmental implications in terms of ground water pollution and air pollution, the latter contributing to global warming. Solid Waste Management is one of the important areas which has been neglected during the past several years. The Muzaffarpur Municipal Corporation (MMC) and the Muzaffarpur Regional Development Authority (MRDA) are unable to provide a fool-proof system to tackle these problems.

The main objectives of this dissertation are to investigate current solid waste management practices and to give proposals for efficient solid waste management for the Muzaffarpur city area. Literature on solid waste management in other cites have been reviewed and data analyzed. The results show a rapid increase in the total amount of municipal solid wastes and significant changes in their composition. Increasing population, urbanization and industrialization are major factors for it. The total solid waste generation has reached up to 0.49 kg per capita per day. Waste analysis indicated a high percentage of food wastes and other compostable products. Different waste treatment options for municipal solid waste have been studied and the factors affecting the important management issues in the operation of Muzaffarpur's solid waste management system have been discussed. Key design data and other useful information selected from a variety of reliable sources are presented.

New sites are proposed for municipal solid waste disposal and treatment. The adoption of modern waste management practices is emphasized in order to achieve greater efficiency. Composting, both aerobic and anaerobic options, are available to the city for scientific disposal of wastes in future. Finally, conclusion, recommendations, proposals and guidelines have been given towards efficient waste management.

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LIST OF ABBREVIATIONS USED

SWM	: Solid Waste Management
SW	: Solid Waste
MSW	: Municipal Solid Waste
MMC	: Muzaffarpur Municipal Corporation
MRDA	: Muzaffarpur Regional Development Authority

INTRODUCTION

1.1 General

Solid wastes are being produced since the beginning of human civilization. During the early period, solid wastes were conveniently and unobtrusively disposed off as the density of population was low with large open land . With the advent of industrialization and urbanization, the problems of waste disposal increased. High population density and intensive land use have led to adverse impact on the environment.

It is a well established fact that the public health is directly related to the management of solid waste. For instance, plague attacks in modern India have been caused due to the neglect of the technological advancements of the waste management in India thereby causing increase in mice population, which are the primary carriers of causative germ of plague. Decision makers, administrations technocrats and planners, therefore, should pay due attention to this problem.

The term 'waste' implies to things of no concern to anyone and is of no value. The intrinsic value of the waste material, as a resource or as an object of further utility, has not been fully recognized.

The development in our urban areas requires that we stop degrading the urban environment, by arresting the unhygienic conditions of our cities and towns. The planners can no longer isolate themselves from the problem of solid waste management among other assets.

When waste is produced more than it can be managed efficiently, such as in large city, more quantity of waste will be produced. and a proper management of solid waste would be much desired. The production of waste is thus directly proportional to the population of a given area. So in a dense area where large

numbers of people live, the waste will be produced more in comparison to same area having lesser population.

Unfortunately, the issue of solid waste management has not attained due attention in India. Ill-managed and inefficient municipal bodies don't pay attention to this problem. Sometimes infectious diseases spread rapidly claiming large number of lives. In the spread of the infectious diseases the dirt in the city acts as catalyst. Solid waste within the residential areas acts as birth place of harmful viruses and bacteria. The environment of city and the health of its inhabitants largely depend on cleanliness of the city. The solid waste management should, therefore, be an important aspect of urban areas which should be adequately dealt with.

Solid waste management involves collection, transport, processing and disposal of solid waste. The attention provided to this falls far short of the known and desired practice which could be attributed to public apathy, entrenched habits and vested interests leading to ineffective management. Adequate information on the management techniques adopted are available, which could be applied with suitable modifications. Such an effort is important to enunciate technological aspects taking into account the differences in waste characteristics, financial constraints and socio-cultural aspects.

1.2 Solid Waste Management

It involves management of activities associated with generation, storage, collection, transfer and transport, processing and disposal of solid waste which is environmentally compatible adopting principles of economy, aesthetics, energy and conservation. It encompasses planning, organization, administration, financial, legal and engineering aspects involving interdisciplinary relationships.

1.3 Outline of Functional Elements

1.3.1 Generation

Waste differs in the rate of generation, quantity and quality depending upon the area of generation. The quantity and quality from residential areas may not vary appreciably. On the other hand, wastes from commercial and industrial areas may vary in quality and quantity at different times of the year. This will have a marked effect on the selection of method for its collection, processing and disposal.

1.3.2 Collection

City dwellers deposit the wastes by the roadside from where the conservancy staff transfers it to the community bins using wheelbarrow or other equipment.

Such primary collection is common in India and other developing countries and needs a large number of workers and significant number of equipment.

1.3.3 Storage

In commercial and industrial areas, the generated waste is stored within the premises; whereas in residential areas, occupants take it out and transfer it to community storage bins. The problem aggravates due to unplanned and haphazard collection of waste (fig 1.1)

Figure 1.1: Unplanned and Haphazard Collection of Waste

1.3.4 Transportation

The material collected in community dustbins is transferred, through transport vehicles, to the processing or disposal site. The fleet of transport vehicles should have sufficient capacity for average and peak loads at optimum levels. In large cities, the material is conveyed to a transfer station from where another set of vehicles transport it further.

1.3.5 Processing and Recovery

A large quantity of waste has to be processed before suitable disposal to reduce its potential nuisance value. Occasionally, recovery of useful constituents is also carried out as an independent process.

1.3.6 Disposal

The waste may be disposed off directly from the disposal site or it may be transported for land-fill sites or water-logged areas for land reclamation .The different functions are interdependent and interrelated which could be better managed by a systems approach. A disposal method, costing less, may not always be the best, option since economy thus achieved may be offset by higher transport or processing cost.

1.4 Aim

Aim of this dissertation is to study the solid waste management system and its improvement for Muzaffarpur City (Bihar, India)

1.5 Objectives

1. To study the existing solid waste disposal system in Muzaffarpur City in terms of:-
   (a) Sources of solid waste
   (b) Solid waste generation
   (c) Existing practices of collection, transportation and disposal
   (d) Municipal Corporation and its role in collecting / managing solid waste

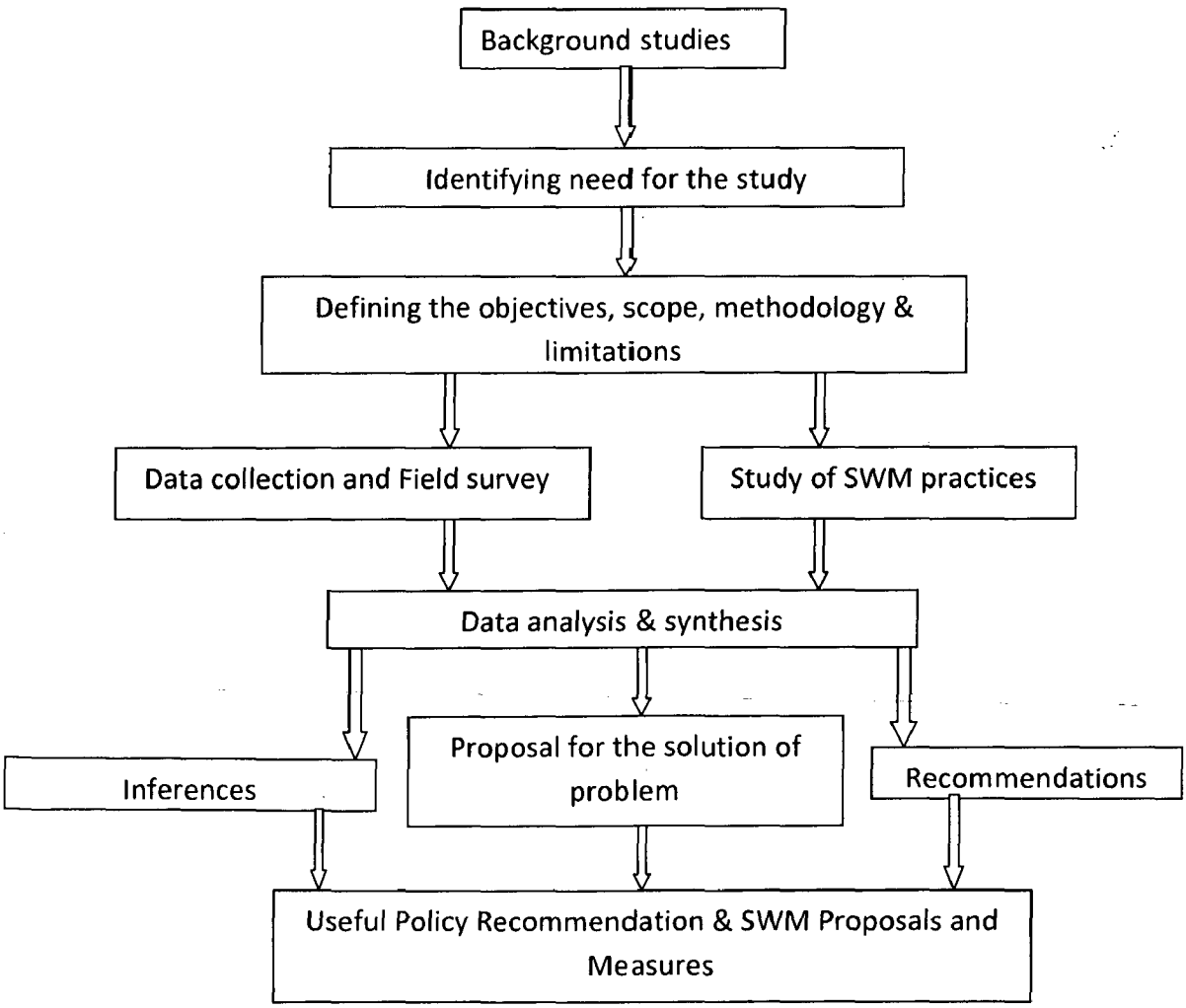
2. Problems encountered in existing practices for solid waste disposal in Muzaffarpur City

3. Providing solution for problems encountered in existing practices.

1.6 Scope / Limitation

1. The study would be limited to solid waste only.
2. The study would be based on the information obtained from Muzaffarpur Municipal Corporation (MMC) and from secondary sources.
3. The study would be within the municipal boundaries of MMC.

1.7 Methodology



1.8 Study Area Muzaffarpur

Muzaffarpur, the district headquarter of Muzaffarpur district (in the Indian state of Bihar), is the largest city of North Bihar. It is situated on the south bank of perennial river *Burhi Gandak*. It has won international encomiums for its delicious *shahi leechi* and *china leechi*.

Muzaffarpur city is one of the several gateways to Nepal due to its proximity to Nepal's southern border. Clothes and food-grains are freely traded between Nepal and Muzaffarpur.

1.9 Problem Identification

General Problems: - Muzaffarpur City, the study area, is an old and densely populated city. It has a density of more than ten thousand eight hundred seventy (10,870) persons per sq km; which is about twelve times the population density of the state of Bihar.

(World Population Density: 40 persons per sq km; Indian Population Density 307 persons per sq km; Bihar Population Density 880 persons per sq km)

1. Its area is only 32.316 sq km with a resident population of 3, 51,285 lacs while it is estimated to be 4.55 lacs including its floating population

2. The new developed area in the southern part of the city is a low-lying area of the city. It is the catchment area of river Punpun which becomes water-logged in every rainy season. The new development in this area increases the cost of infrastructural facilities due the water logging problem. This water has to be pumped out of the area for carrying out any developmental activity.The circle in the plan shows the water-logged area. Various new departments under state / central government have come up to solve the water-logging problem of the city.

(a) The population pressure on the city has led to the unplanned development of the city. The municipal body is not able to maintain this unplanned development. Moreover, in absence of efficient management of the city, the municipal body is not able to generate sufficient revenue to run itself and to meet city's requirements.

(b) The divisions of the municipal wards are uneven. Some wards are very large while others are rather small; some are very dense while others are thinly populated.

1 The Wiswas Board which is responsible for the cleaning of the drains, cleans the drains and leaves the waste from the drains on the road side, which remains unattended .It's neither claimed by the Wiswas Board nor by the MMC.

2 Because of irregular and hap-hazard (and thus complex) development; various agencies often overlap their duties thereby increasing the operational costs. In a residential area, commercial as well as industrial activities all run simultaneously. All the types of activities pay taxes of residential area or more than one type of taxes have to be collected from same area; resulting in loss in the revenue for MMC.

1.10 SWM Management in Muzaffarpur

In the 32.316 sq km area of the Muzaffarpur city, 478 tonnes of solid waste is generated out of which only 60 to 70 percent is disposed off daily.

The types of solid waste generated are:-

1. Domestic (54 %)	258 tonnes
2. Commercial (31 %)	148 tonnes
3. Industrial and Constructional debris (13 %)	62 tonnes
4. Hospital (2 %)	10 tonnes

(a) Collection:- People generally throw the solid waste beside the roads. There is virtually no provision of bins for the people so that they can't dump the solid waste appropriately .From there, sanitary workers collect the SW in wheel barrows and dump it in the dumping points. From the dumping points MMC staff collects SW in tractors and carries it to the land-fill points.

(b) Disposal:- All the types of solid waste generated is presently disposed off by MMC. Any type of segregation method is not applied during the disposal. The MMC staff simply collects the waste and disposes it off in the dumping points.

1.11 Problems Related to Solid Waste Management

(a) The MMC lacks in proper staff, set up and fleet of vehicles,

(b) There is no proper system of solid waste management. Garbage bins are not placed properly at regular intervals.

(c) The disposal vehicles carry the SW uncoverd, which go on littering the SW here and there on the roads.

(d) Only land-fill disposal technology is involved, there is no gradation or classification of the SW before disposal.

(e) There is no provision for disposal of hazardous waste. There are about 90 identified big Medical Health Establishments (hospitals and nursing homes, etc) which have been directed to use incinerators for the disposal of hazardous waste. But these Establishments are not using the incinerators.

(f) Commercial establishments like hotels which produce large amount of bio-degradable waste, depend on the municipal corporation for the disposal.

(g) In the Muzaffarpur city there are many cottage and small scale industries in operation but they depend on the MMC for the disposal of their industrial waste. There is no separate system for the disposal of industrial waste. The MMC staffs just dump the industrial waste in the open land.

(h) Sometimes cottage industries put their waste in drains, a practice which results in chocking of the drains,

(i) There are no fixed points for the collection of SW; people just throw the waste anywhere they like on the road sides.

(j) Sometimes the disposal vehicles pass through the roads at peak load hours on the congested roads.

(k) The major roads are not swept regularly; minor roads are swept occasionally or never,

(l) Sweepers don't attend their duty regularly,

(m) The MMC has no fixed and regular disposal land-fill points.

(n) There is no enough land for the future development of Muzaffarpur city. So in future, with the increase in population, the existing disposal points will also disappear,

(o) The MMC has no incineration plant of its own to process the hazardous waste.

(p) In the rainy season, the SW rots in low lying areas and becomes instrumental in spreading water-borne diseases.

LITERATURE STUDY

LITERATURE STUDY: 1

What a Waste: Solid Waste Management in Asia
(Urban Development Sector Unit: East Asia and Pacific Region)

2.1 Introduction: Solid Waste Management in Asia

As urbanization and economic development increases in Asia, nowhere is the impact more obvious than in society's *detritus*, or solid waste. Today, the urban areas of Asia produce about 760,000 tonnes of municipal solid waste (MSW) per day, or approximately 2.7 million m^3 per day. By 2025, this figure will increase to 1.8 million tonnes of waste per day, or 5.2 million m^3 per day. These estimates are conservative, the real values are probably more than double this amount. Local governments in Asia currently spend about US $ 25 billion per year on urban solid waste management. This amount is used to collect more than 90 percent of the waste in high income countries, between 50 and 80 percent in middle income countries, and only between 30 and 60 percent in low income countries.

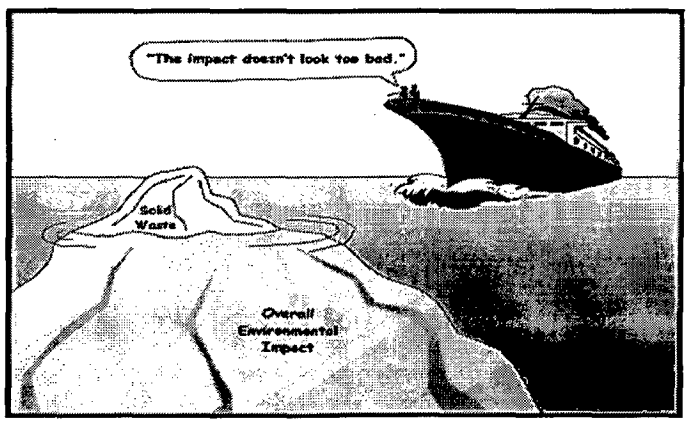


Figure 2.1: The Apparent and Hidden Magnitude of Overall Environmental Impact of Solid Waste.

By 2025, Asian governments should anticipate spending at least double this amount (in 1998 US dollars) on solid waste management activities.

To carry out integrated solid waste management, local governments need partners. National governments must reduce the externalities of waste by

considering measures such as full cost accounting, package deposits, manufacturer responsibility, and extended product care.

The general community which is probably the most important stakeholder in waste management activities must also actively participate in the solutions by modifying their behavior patterns. For example, they need to exert discipline in separating waste, using containers in a beneficial way, and exercising environment-friendly purchasing habits.

This paper reviews the broad trends related to solid waste management in Asia.(*Asia in this report is limited to China, Japan, Hong Kong, Republic of Korea, Mongolia, Indonesia, Lao PDR, Malaysia, Myanmar, Philippines, Singapore, Thailand, Vietnam, Bangladesh, India, Nepal and Sri Lanka*). 'The big picture' projects regional urban MSW quantities and compositions in 2025 (Please refer Tables 2.1, 2.2 and 2.3). The forces of these trends are analyzed, and preliminary suggestions for reducing the impact of these trends are provided. The paper also briefly discusses possible policies and budget requirements for dealing with this burgeoning waste stream. This paper contains one of the most comprehensive collections of solid waste generation data. In compiling these data, the authors identified shortcomings with terminology used and sampling methods and built-in problems with consistency.

In the *Annex-1* of this report, recommendations are made to help overcome these limitations and for improving solid waste data collection and presentation.

Its *Annex-2* (Here reproduced as Tables 2.7, 2.8 and 2.9) presents waste generation rates for selected Asian cities.

It is beyond the scope of this paper to venture into the debate on *the limits to growth vis-a-vis resource consumption* or the negative environmental impacts that will occur from wastes generated by an increasingly consumerist one billion urban Asians.

The fear about these effects, however, is warranted, particularly since nearly 95 percent of environmental damage occurs before a product is discarded as solid waste. This paper discusses the concern about environmental effects associated with solid waste management as well as the escalating costs that solid waste

management consumes from local government budgets and how to handle these increases.

This paper focuses on waste management only as it pertains to urban environments, based on:

a. projections that in 2025 about 52 percent of Asia's population will reside in urban areas, and

b. evidence that urban residents generate at least two times more waste per capita than their rural counterparts.

Although urban waste management data may be inconsistent and unreliable, rural solid waste management data are virtually non-existent and are derived only from assumptions regarding purchasing habits. Given these factors, it is clear that solid waste management efforts must target priority urban areas.

This paper does not review *where the waste goes*. A follow-up study that reviews composting rates (existing and potential), recycling (existing programs, potential markets), number and working conditions of waste-pickers would be a valuable contribution to municipal waste management planning.

2.2 Waste Characterization

Solid waste streams should be characterized by their sources, by the types of wastes produced, as well as by generation rates and composition. Accurate information in these three areas is necessary in order to monitor and control existing waste management systems and to make regulatory, financial, and institutional decisions.

Annex-1 of this report discusses in detail reliability issues and compositions of waste data. Better consistency in definition and methodology is needed. Although this paper contains one of the most comprehensive compilations of MSW data for Asia, readers are advised to exercise caution in interpreting the data. Severe under-recording of waste quantities is typical, and total waste generation is usually much higher than that reported by government agencies.

One important observation shown in *Annex-1* of the report is that apart from localized anomalies, such as the use of coal for cooking and heating, urban waste

generation rates are generally consistent *vis-a-vis* local economic activity and residential wealth. Because waste characterization studies are relatively expensive to conduct, the general '*rules of thumb*' provided in this paper should provide sufficient direction for the purposes of waste management planning.

In the context of this paper, waste is defined as any unwanted material intentionally thrown away for disposal. However, certain wastes may eventually become resources valuable to others once they are removed from the waste stream. This definition of waste may differ somewhat from definitions used by other international data sources.

Knowledge of the sources and types of solid waste in an area is required in order to design and operate appropriate solid waste management systems (Please refer Figure 2.2).

There are eight major classifications of solid waste generators: residential, industrial, commercial, institutional, construction and demolition, municipal services, process, and agricultural. MSW includes wastes generated from residential, commercial, industrial, institutional, construction, demolition, process, and municipal services. However, this definition varies greatly among waste studies, and some sources are commonly excluded, such as industrial, construction and demolition, and municipal services. Often only residential waste is referred to as MSW, and in high income countries, only 25 percent to 35 percent of the overall waste stream is from residential sources. It is important to define the composition of the municipal waste stream in a clear and consistent fashion. For example, if this municipal waste stream includes construction and demolition waste, the quantity of waste is doubled. Far too often, waste management decisions are based disproportionately on residential waste, which accounts for an increasingly small fraction of the waste stream as an area industrializes.

Source	Typical waste generators	Types of solid wastes
Residential	Single and multifamily dwellings	Food waste, paper, cardboard, plastics, textiles,leather, yard wastes, wood, glass, metals, ashes, special wastes (e.g., bulky items, consumer electronics, white goods, batteries, oil, tires), and household hazardous wastes
Industrial	Light and heavy manufacturing, fabrication, construction sites, power and chemical plants	Housekeeping wastes, packaging, food wastes, construction and demolition materials, hazardous wastes, special wastes
Commercial	Stores, hotels, restaurants, markets, office buildings, etc.	Paper, cardboard, plastics, wood, food wastes, glass, metals, special wastes, hazardous wastes
Institutional	School, hospitals, prisons, government centers	Same as commercial
Construction and demolition	New construction site, rood repair, renovation sites, demolition of buildings	Wood, steel, concrete, dirt, etc.
Municipal services	Street cleaning, landscaping, parks, beaches, other recreational areas, water and wastewater treatment plants	Street sweepings; landscape and tree trimmings; general wastes from parks, beaches, and other recreational areas; sludge
Process	Heavy and light manufacturing, refineries, chemical plants, power plants, mineral extraction and processing	Industrial process wastes, scrap materials, off-specification products, slag, tailings
All of the above should be included as 'municipal solid waste'		
Agriculture	Crops, orchards, vineyards, dairies, feedlots, farms	Spoiled food wastes, agricultural wastes, hazardous wastes (e,g.,pesticides)

Figure 2.2: Sources and Types of Solid Waste

2.3 Composition of Urban Solid Waste In Asian Countries

Table 2.1: Composition of Urban Solid Waste in Low Income Countries

Components	Nepal	Bangladesh	Myanmar	Lao PDR	India	Sri Lanka	China	Current	Est.
1995 Urban Population (in millions)	2.9	21.9	12.2	1.1	249.1	4.1	363.7	655	1,525.70
Year	1994	1992	1993	1998	1995	1993-94	1991-95		2025
Type of waste	MSW	Dom	Dom, Com	Dom, I C & I	MSW	Dom, Com	Dom, Com, MSW		MSW
Compostables	80	84.37	80	54.3	41.8	76.4	35.8	41.0	60
Paper	7	5.68	4	3.3	5.7	10.6	3.7	4.6	15
Plastic	2.5	1.74	2	7.8	3.9	5.7	3.8	3.8	6
Glass	3	3.19	0	8.5	2.1	1.3	2	2.1	3
Metal	0.5	3.19	0	3.8	1.9	1.3	0.3	1.0	4
Others	7	1.83	14	22.5	44.6	4.7	54.3	47.5	12

Source: What a Waste: Solid Waste Management in Asia, May 1999.

1. Nepal based on Kathmandu Valley.
2. Bangladesh based on Dhaka.
3. Myanmar based on Yangon.
4. Lao PDR based on Vientiane and Khanthabouri.
5. India based on 23 metro cities.
6. Sri Lanka based on Colombo, Kandy, and Galle.
7. China based on Qujing, Guilin, Dalian, Wuhan, Beijing, Huangshi, Xiangfan, and Yichang.

Table 2.2: Composition of Urban Solid Waste in Middle Income Countries

Components	Indonesia	Philippines	Thailand	Malaysia	Current	Est. 2025
1995 Urban Population	68.4	37.2	11.6	10.8	128	296.7
Year	1993	1995	1995-96	1990		2025
Type of waste	MSW	n/i	n/i	n/i		MSW
Compostables	70.2	41.6	48.6	43.2	57.5	50
Paper	10.9	19.5	14.6	23.7	14.9	20
Plastic	8.7	13.8	13.9	11.2	10.9	9
Glass	1.7	2.5	5.1	3.2	2.4	3
Metal	1.8	4.8	3.6	4.2	3.1	5
Others	6.2	17.9	14.2	14.5	11.1	13

Source: What a Waste: Solid Waste Management in Asia, May 1999.

1. Indonesia based on Jakarta, Bandung, and Surabaya.
2. Philippines based on Metro Manila, Batangas, Olongapo, and Baguio.
3. Thailand based on Bangkok, and the Municipalities of Chonburi, Rayong, Songkhla, and Chiangmai.
4. Malaysia based on 11 municipalities.

Table 2.3: Composition of Urban Solid Waste in High Income Countries

Components	Singapore	Japan	Hong Kong	Current	Est. 2025
1995 Urban Population	3	98.2	5.9	106.1	112.3
Year	1990	1993	1995		2025
Type of waste	MSW	n/i	Dom		MSW
Compostables	44.4	26	37.2	27.8	33
Paper	28.3	46	21.6	36.0	34
Plastic	11.8	9	15.7	9.4	10
Glass	4.1	7	3.9	6.7	7
Metal	4.8	8	3.9	7.7	5
Others	6.6	12	17.6	12.2	11

Source: What a Waste: Solid Waste Management in Asia, May 1999

1. Singapore based on the entire country.
2. Japan based on Metropolitan Tokyo.
3. Hong Kong based on the entire country.

2.4 Waste Generation Rates

Waste generation rates are affected by socio-economic development, degree of industrialization, and climate. Generally, the greater the economic prosperity and higher the percentage of urban population, the greater the amount of solid waste produced. Figure-2.3 compares and contrasts the urban waste composition and the total amount of waste generated by the current and future populations for these countries. Figure 2.4 gives urban MSW generation rates, as a weighted average of the waste data available from various cities.

Waste composition of low, middle, and high income countries

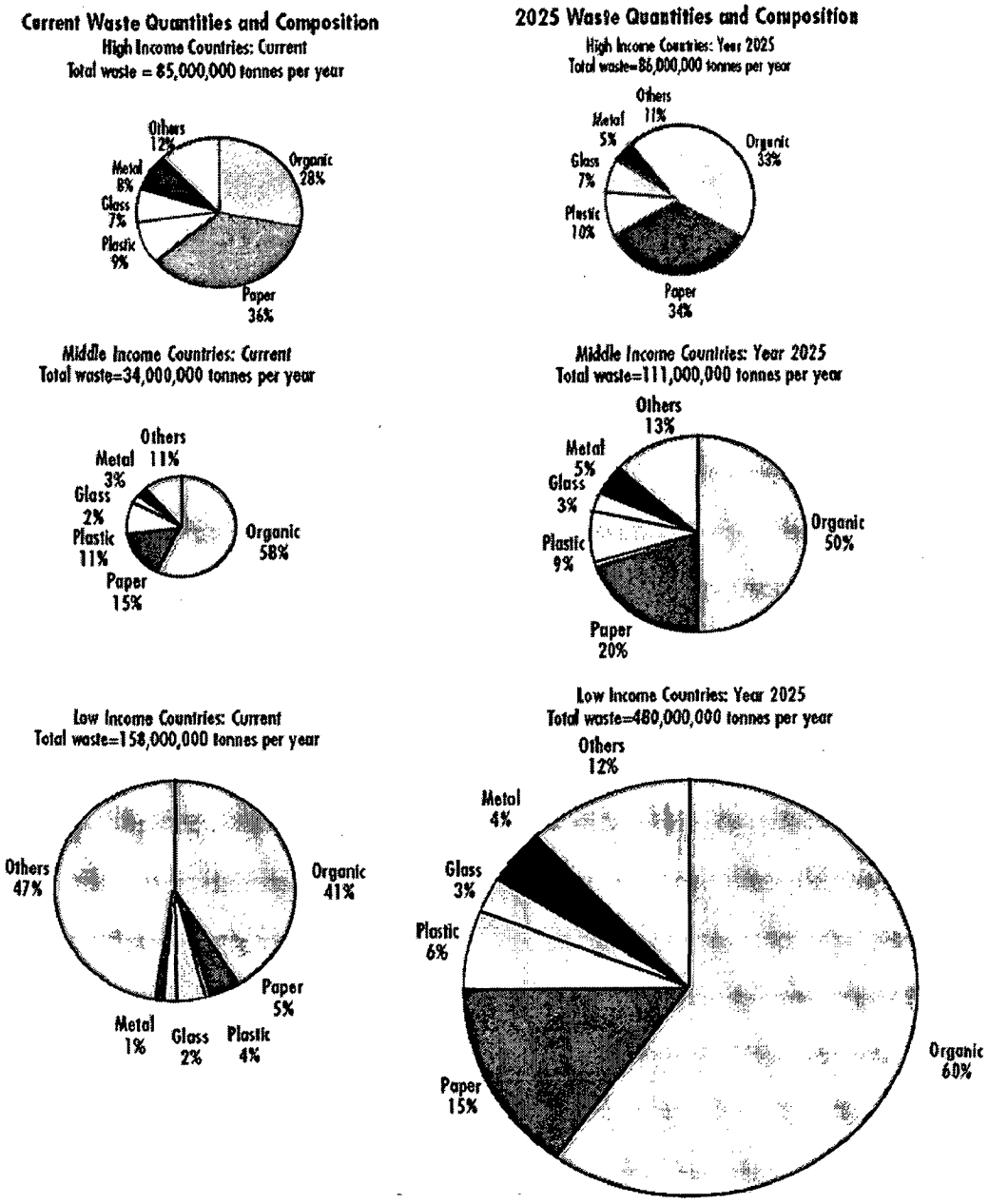


Figure 2.3: Waste Generation Rates and Waste Composition of Low, Middle, and High Income Countries of Asia.

Source: What a Waste: Solid Waste Management in Asia, May 1999.

Low income countries have the lowest percentage of urban populations and the lowest waste generation rates.

Comparing generation rates for various countries is problematic. As demonstrated by Hong Kong, Singapore, and Japan, global inconsistencies in the way municipal solid waste is defined and quantified can lead to significant differences among the 'official' waste generation rates.

As mentioned previously, very little information about rural waste generation rates in Asian countries is available; however, one can assume that rural populations will generate less waste because these areas have lower per capita incomes. Urbanization and rising incomes, which lead to more use of resources and therefore more waste, are the two most important trends that factor into rising waste generation.

Individuals living in Indian urban areas use nearly twice as many resources per capita than those living in a rural setting. Because they consume and generate more solid waste, the Indian urban population is expected to produce far more waste per capita than its rural population.

Historical waste generation patterns of both developed and developing countries, economic trends, and population predictions, and per capita municipal solid waste generation rates and compositions are estimated for Asian countries in 2025 (Please refer Tables 2.4 & 2.5).

Table 2.4: Current Urban Per Capita Municipal Solid Waste Generations

Country	GNP Per Capita (1995 US $)	Current Urban Population (% of Total) sq	Current Urban MSW Generation (kg/capita/day)
Low Income	**490**	**27.8**	**0.64**
Nepal	200	13.7	0.50
Bangladesh	240	18.3	0.49
Myanmar	240	26.2	0.45
Vietnam	240	20.8	0.55
Mongolia	310	60.9	0.60
India	340	26.8	0.46
Lao PDR	350	21.7	0.69
China	620	30.3	0.79
Sri Lanka	700	22.4	0.89
Middle Income	**1,410**	**37.6**	**0.73**
Indonesia	980	35.4	0.76
Philippines	1,050	54.2	0.52
Thailand	2,740	20.0	1.10
Malaysia	3,890	53.7	0.81
High Income	**30,990**	**79.5**	**1.64**
Korea, Republic of	9,700	81.3	1.59
Hong Kong	22.990	95.0	5.07
Singapore	26,730	100	1.10
Japan	39.640	77.6	1.47

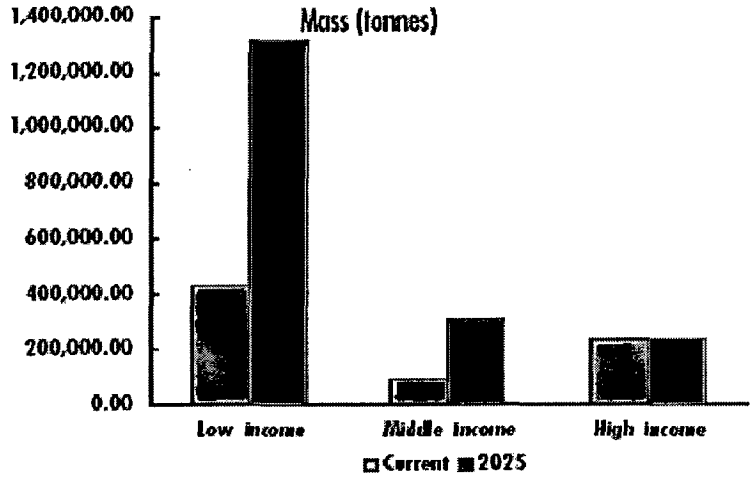
Source: What a Waste: Solid Waste Management in Asia, May 1999.

Table 2.5: Urban Per Capita Municipal Solid Waste Generation, 2025

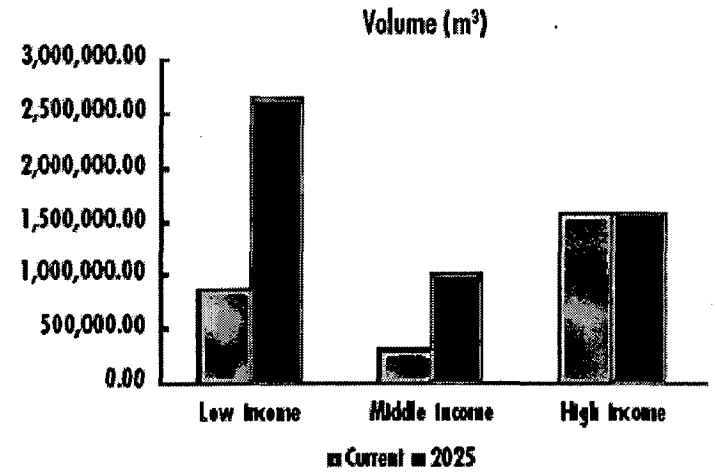
Country	GNP Per Capita In 2025 (1995 US $)	2025 Urban Population (% of Total) sq	2025 Urban MSW Generation (kg/capita/day)
Low Income	**1,050**	**48.8**	**0.6-1.0**
Nepal	360	34.3	0.6
Bangladesh	440	40.0	0.6
Myanmar	580	47.3	0.6
Vietnam	580	39.0	0.7
Mongolia	560	76.5	0.9
India	620	45.2	0.7
Lao PDR	850	44.5	0.8
China	1,500	54.5	0.9
Sri Lanka	1,300	42.6	1.0
Middle Income	**3,390**	**61.1**	**0.8-1.5**
Indonesia	2,400	60.7	1.0
Philippines	2,500	74.3	0.8
Thailand	6,650	39.1	1.5
Malaysia	9,400	72.7	1.4
High Income	**41,140**	**88.2**	**1.1-4.5**
Korea, Republic of	17,600	93.7	1.4
Hong Kong	31,000	97.3	4.5
Singapore	36,000	100.0	1.1
Japan	53,500	84.9	1.3

Source: What a waste: solid waste management in Asia, may 1999.

2.5 Total Waste Quantities and Volumes Generated by Low, Middle and High Income Countries (Per Day)



Graph 2.1: Total Waste Quantities Generated by Low, Middle and High Income Countries (Per Day)



Graph 2.2: Total Waste Volumes Generated by Low, Middle and High Income Countries (Per Day)

Source: The International Bank for Reconstruction and Development / The World Bank 1818, H Street, N.W., Washington, D.C. 20433, USA

As a whole, urban population from low and middle income countries will triple their current rate of municipal solid waste generation over the next 25 years. Nepal, Bangladesh, Myanmar, Vietnam, Lao PDR, and India can each expect their urban waste quantities to increase by about four to six times the current amount. By 2025, the low income countries will generate more than twice as much municipal waste than all of the middle and high income countries combined--approximately 480 million tonnes of waste per year. Such a dramatic increase will place enormous stress on limited financial resources and inadequate waste management systems.

In 2025, the high income countries are expected to generate about the same quantity of waste in terms of both mass and volume. Low income countries will be the largest generator of wastes on a mass basis, and will also surpass the total volume of waste produced by the high income countries.

Table 2.6: Global Paper Consumption Rates (1995)

Country	Per capita Paper Consumption(kg/year)	Per capita GNP sq.(1995 US $)
USA	313	26,980
Japan	225	39,640
Hong Kong	220	22,990
Germany	190	27,510
United Kingdom	170	18,700
Australia	152	18,720
South Korea	128	9,700
Malaysia	62	3,890
Chile	39	4,160
Poland	31	2,790
Russia	30	2,240
Thailand	30	2,740
Brazil	28	3,640
Bulgaria	20	1,330
China	17	620
Egypt	11	790
Indonesia	10	980
Nicaragua	4	380
India	3	340
Nigeria	3	260
Ghana	1	390
Lao PDR	1	350
Vietnam	1	240

Source: What a waste: solid waste management in Asia, may 1999.

2.6 Solid Waste Data

Waste data, including both generation rates and composition, should be considered with a degree of caution due to global inconsistencies in definitions of common terms and methodologies.

In most low and middle income countries, the reliability of solid waste data is further reduced by large seasonal variations (e.g., seasonal rains and uncontainerized waste), incomplete waste collection and disposal (e.g., significant level of waste is disposed off directly by the generator by burning or throwing in waterways and low-lying areas), and a lack of weigh scales at landfill sites to record waste quantities.

"Other-consumer products" consist of bulky wastes, household appliances, electronics, and multi-material packaging (e.g., tetra-packs and blister packaging). This waste stream is much more significant in high income countries and differs from "other-residue" in that the volumes are much higher per kilogram of waste and are generally combustible.

Table 2.7. Shows solid waste moisture contents and densities as reported by specific cities. Usually the higher the percentage of organic matter, the higher the moisture content and the density of the waste stream. The waste density of low income countries such as China, India, and Mongolia is further influenced by significant quantities of discarded coal ash residue. Low income countries have a wet waste density typically between 350 and 550 kg/ m^3, middle income countries range from 200 to 350 kg/ m^3 and high income countries from 150 to 300 kg/ m^3.

Table 2.7: Solid Waste Moisture Contents and Densities

City, Country	Moisture content (%)	Density(kg/ m^3)
Low income countries		350-550
Yangon, Myanmar	n/a	400
Chongqing,China	42.5	550
Qujing,China	30.0	554
Dalian,China	49.7	400
Middle income countries		200-350
Bangkok,Thailand	49.1	350
ChonburiMunicipality,Thailand	56.3	210
Rayong Municipality,Thailand	46.7	240
Batangas,Philippines	27.4	262
Metro Manila, Philippines	45.0	n/a
Kuala Lumpur,Malaysia	n/a	270
High income countries		150-300
Seoul,South Korea	n/a	302
Yokohama,japan	45.0	n/a

2.7 Organization for Economic Co-Operation and Development (OECD)

Table 2.8: Municipal Solid Waste Generation Rates

Country	Year	MSW Generation Rate(kg/capita/day)	Population	Total Waste (tones/day)
USA	1992	2	263.1	526.200
Australia	1992	1.89	18.1	34,209
Canada	1992	1.8	29.6	53,280
Finland	1990	1.7	5.1	8,670
Iceland	1992	1.53	0.3	459
Norway	1992	1.4	4.4	6,160
The Netherlands	1992	1.37	15.5	21,235
France	1992	1.29	58.1	74,949
Denmark	1992	1.26	5.2	6,552
Austria	1990	1.18	8.1	9,558
Japan	1992	1.12	125.2	140,224
Belgium	1992	1.1	10.1	11,110
Switzerland	1992	1.1	7	7,700
Turkey	1992	1.09	61.1	66,599
Hungary	1992	1.07	10.2	10,914
Sweden	1990	1.01	8.8	8,888
Germany	1990	0.99	81.9	81,081
Spain	1992	0.99	39.2	38,808
Italy	1992	0.96	57.2	54,912
Poland	1992	0.93	38.6	35,898
Portugal	1992	0.9	9.9	8,910
Mexico	1992	0.85	91.8	78,030
Greece	1992	0.85	10.5	8,925

Source: What a waste: solid waste management in Asia, may 1999.

Table 2.9: Municipal Solid Waste Compositions (Percentage), 1993 OECD

Country	Organic	Paper	Plastic	Glass	Metal	Other
Canada	34	28	11	7	8	13
Mexico	52	14	4	6	3	20
USA	23	38	9	7	8	16
Japan	26	46	9	7	8	12
Australia	50	22	7	9	5	8
Denmark	37	30	7	6	3	17
Finland	32	26	0	6	3	35
France	25	30	10	12	6	17
Greece	49	20	9	5	5	13
Luxembourg	44	20	8	7	3	17
Netherland	43	27	9	4	5	8
Norway	18	31	6	4	5	36
Portugal	35	23	12	5	3	22
Spain	44	21	11	7	4	13
Switzerland	27	28	15	3	3	24
Turkey	64	6	3	2	1	24
Average	38	26	8	6	5	18

Source: What a waste: solid waste management in Asia, may 1999.

2.8 SWM IN INDIA

2.8.1 Disposal of Waste

Almost all the cities have adopted open dumping for disposal of waste except at Pune, where sanitary landfill is under development and at Nasik where waste disposal is carried out in different cells

Adopting a method of sanitary land filling, the leachate collection and treatment, and also biogas recovery from landfills are not practiced in most of the cities. Earth cover is provided partly in few cities including Mumbai, Kolkata, Chennai, Ahmadabad, Kanpur, Lucknow, Nasik, Vadodara, Jamshedpur, Allahabad, Amritsar, Rajkot, Shimla, Thiruvananthapuram and Dehradun. Compaction of waste is carried out by the compactor/bulldozer in 26 cities.

In hilly region cities, disposal of waste is carried out along the valley ridges. The facilities such as fencing around the landfill, check-post, firefighting, water, electricity, record maintenance, approach roads, plan for filling of different cells of the landfill in different seasons of the year are not available.

2.8.2 The Most & the Least Favoured of SWM

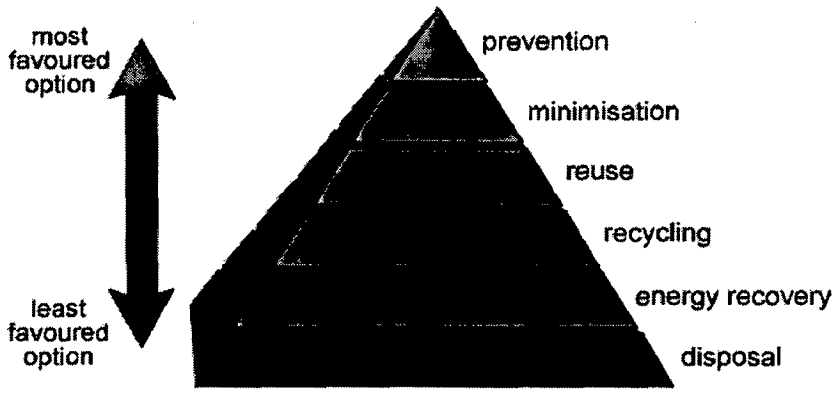


Figure 2.4: The Most & the Least Favoured of SWM

2.8.3 Effective Solid Waste Management Chart

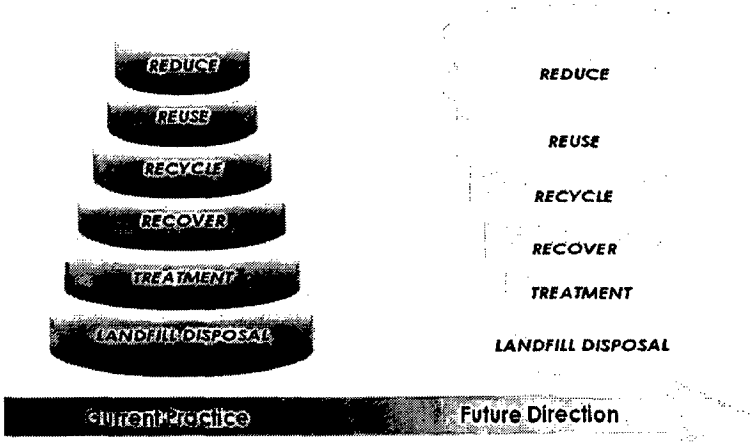


Figure 2.5: Effective Solid Waste Management Chart

2.8.4 Integrated Solid Waste Management

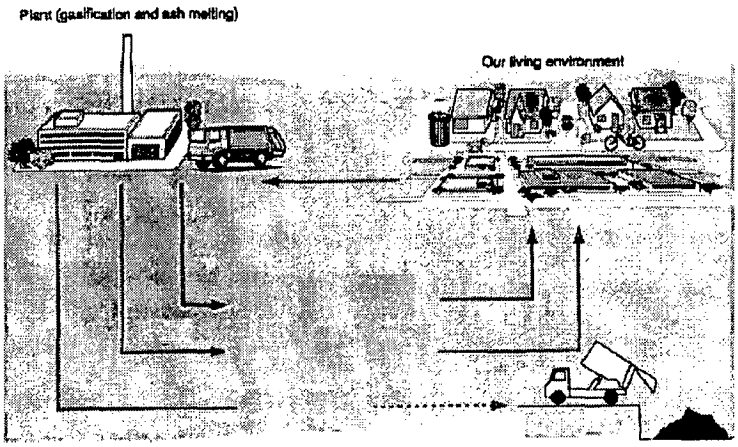


Figure 2.6: Integrated Solid Waste Management

LITERATURE STUDY: 2

2.2.1 Sources and Types of Solid Waste:

Table 2.10 shows the sources and types of solid waste produced generally in the Asian countries and their respective compositions.

Table 2.10: Showing Sources and Types of Solid Waste

Sources and types of solid waste		
Source	**Typical waste generators**	**Types of solid waste**
Residential	Single and multi-family dwelling	Food, waste paper, card board, plastic, textile, leather, yard waste, wood ,glass, metal, ash, special waste(bulky item, consumer electronics, white goods, batteries, oil, tyres) and household hazardous waste.
Industrial	Light and heavy manufacturing fabrication, construction sites, power and chemical plants	Housekeeping waste, packaging and demolition materials, hazardous materials, hazardous waste, ashes, special waste.
Commercial	Store, hotel, market, office building, etc.	Paper, card board, plastic, wood, food, waste, glass, metal, and special waste.
Institutional	School, hospital, prison, government centres	Same as commercial
Construction and demolition	New construction site, road repair, renovation site, demolition of building	Wood, steel, dirt, etc.
Municipal services	Street clearing, landscaping, parks, benches, other recreational areas, water and waste treatment plants	Street sweeping, landscaping, tree trimming, general waste from parks, benches and other recreational areas.
Process	Heavy and light manufacturing refineries, chemical plants, power plants, mineral plants extraction and processing	Industrial process waste, scrap materials of specific products, slag.
All the above waste should be treated as municipal waste		
Agriculture	Crops, orchards, vineyards dairies, feed farms.	Special food waste, agricultural waste, hazardous waste (e.g. plastic)

2.2.2 Composition of Low Middle Generation Rate Asian countries and their GNP

The countries are grouped in three different categories of income groups and waste generation rates which depend on their GNP.

Table 2.11 shows the consumption rates of different commodities like agricultural products and other commodities. (Direct and indirect per capita consumption in India, 1989-90, Rs/annum).

The consumption rate influences the MSW production.

Table 2.11: Consumption Rates of Different Commodities

Commodities	Rural per capita consumption	Urban per capita consumption
Sugar Cane	84.35	79.34
Cotton	58.34	94.0
Coal & Lignite	33.73	81.69
Crude petroleum & natural gas	60.34	162.03
Iron ore	0.37	0.81
Other metallic elements	2.23	5.23
Cement	4.08	7.88
Electricity gas and water supply	121.53	269.69
All commodities	**4996.95**	**9720.20**
Population in millions	606.6	204.6
Percentage of population	74.8	24.2
Parikhetal, cited in Hammond, 1998		

2.2.3 Amount of Waste Generated In the Asian Countries and Solid Waste Management Costs

MacFarlane (1998) highlights a relationship between per capita solid waste management costs and per capita GNP. As shown in Table 2.13, cities in both developing and industrialized countries generally do not spend more than 0.5 percent of their per capita GNP on urban waste services. The 0.5 percent GNP value can be used by low and middle income countries as a general guideline to prepare waste management budgets and for planning. These costs, however, are only about one third of the overall total. Additional costs are paid by businesses and residents, exclusive of municipal taxes and fees, Hoornweg (1992). In Japan, municipal governments are responsible for solid waste management services and spend about 2,280 billion).

Figure 2 shows a comparative statement of waste generated by different countries according to the income group. Industrialized countries comprise only 16 percent of the world's population, but they currently consume approximately 75 percent of global paper production. As shown in Table 2.12, India, Indonesia and China are three of the world's foremost populous countries and among the lowest consumers of paper per capita. However, as their GNP and urban populations grow, their paper consumption and related packaging wastes will also increase. If they follow industrialized countries, their paper requirement will be enormous.

Table 2.12: Municipal Waste Services Expenditure (MWSE)

City country	Year	Per capita expenditure on SMW (US$)	Per capita GNP (US $)	%GNP spent on SWM
New York USA	1991	106	22240	0.48
Troronto Canada	1991	67	20440	0.33
Strasboursg, France	1995	63	24990	0.25
Kuala Lumpur	1994	15.25	4000	0.38
Budapest, Hungry	1995	13.80	4130	0.33
Sao Paulo, Brazil	1989	13.32	2540	0.52
Tallinm, Estonia	1995	8.11	3080	0.47
Bogota, Colombia	1994	7.75	1620	0.48
Caracas, Venezuela	1989	6.67	2450	0.27
Rigo, Latvia	1995	6	2420	0.25
Manila, Philipines	19958	NA	1070	0.37
Bucharest, Romania	1995	2.37	1450	0.16
Manila, Philippines	1995	NA	1070	0.37
Budapeat, Romania	1995	2.37	1450	0.16
Hanio, Vienna	1994	Predict	250	0.80
Madras, India	1995	1.77	350	0.51
Lahore, Pakistan	1985	1.77	390	0.45
Dhaka, Bangladesh	1995	1.46	270	0.54
Accro, Ghana	1994	0.66	390	0.17
Macfarlane, 1998				

According to a 1992 study by the Indonesian Environmental Forum (Djuweng, 1997), Indonesian per capita paper consumption rose by 11.2 percent between 1981 and 1989 to meet local and international market demands and to fulfill its intention of becoming the world's largest pulp and paper producing country (Please refer table 2.13).

Table 2.13: Global Paper Consumption Rates

Country	Per capita paper consumption (kg/yr)	Per capita GNP (1995 US $)
USA	313	26980
Japan	225	36480
Honkong	220	22990
Germany	190	27510
United Kingdom	170	18700
Australia	152	18720
South Korea	128	9700
Malaysia	62	3890
Chile	39	4160
Poland	31	2790
Russia	30	2240
Thailand	30	2270
Brazil	28	3640
Bulgaria	20	1330
China	17	620
Egypt	11	780
Indonesia	10	790
Nicaragua	4	380
India	3	340
Nigeria	1	260
Ghana	1	390
Loop PDR	1	350
Vietnam	1	240

Djuweng world bank 1977b

2.2.4 Impacts of Improper Solid Waste Management

Improper solid waste management causes all types of pollution: air, soil, and water. Indiscriminate disposal of solid waste contaminates surface and ground water supplies. In urban areas, solid waste clogs drains, creating stagnant water for insect breeding and floods during rainy seasons. Uncontrolled burning of wastes and improper incineration contributes significantly to urban air pollution. Greenhouse gases are generated from the decomposition of organic wastes in landfills, and untreated leachate pollutes surrounding soil and water bodies.

These negative environmental impacts are only a result of solid waste disposal; they do not include the substantial environmental degradation resulting from the extraction and processing of material at the beginning of the product life cycle. In fact, as much as 95 percent of an item's environmental impact occurs before it is discarded as MSW. Health and safety issues also arise from improper solid waste management. Human fecal matter is commonly found in municipal waste. Insect and rodent vectors are attracted to the waste and can spread diseases such as cholera and dengue fever. Using water, polluted by solid waste, for bathing, food, irrigation, and drinking can also expose individuals to disease organisms and other contaminants.

U.S. Public Health Service identified 22 human diseases that are linked to improper solid waste management (Hanks, 1967, cited in Tchobanoglous et al. 1993).

Waste workers and pickers in developing countries are seldom protected from direct contact and injury and the co-disposal of hazardous and medical wastes with municipal wastes poses serious health threat. Table 2.14 shows the urban per capita MSW generation rates according to different income groups of different countries and Table 2.15 provides a comparative study of the costs, land filling, incineration, collection, recycling and composting.

Table 2.14: Urban Per Capita MSW Generation of Low, Middle and High Income Asian Countries

Country	GNP per capita in 2025 (1995 US $)	2025 urban population % of total	2025 MSW generation (kg/capita/per day)
Low income	**1050**	**48.8**	**0.6-1.0**
Nepal	360	34.3	0.6
Bangladesh	440	40.0	0.6
Myanmar	580	47.3	0.6
Vietnam	280	39.0	0.7
Magnolia	560	76.5	0.9
India	620	45.2	0.7
Low PDR	850	54.5	0.8
China	1500	45.5	0.9
Shrilanka	1300	42.6	1.0
Middle income	**3390**	**61.1**	**0.85-1.5**
Indonesia	2400	60.7	1.0
Philippines	2500	60.7	1.0
Thailand	6650	39.1	1.0
Malaysia	9400	72.1	1.4
High income	**41140**	**88.2**	**1.1-1.4**
Korea	17600		1.4
Hongkong	3100		4.5
Singapore	36000		1.1
Japan	53500		1.3

. United nations 1995

Table 2.15: Comparison of Various Activities of Typical Solid Waste Management System among Low, Middle and High Income Asian Countries

Activity	Low income	Middle income	High income
Sources reduction	No or organized programmes, but reuse and low per capita waste generation rate are common	Some discussion of source reduction but rarely incorporated to any organized programme	Organized educational programmes are beginning to introduce sources reduction and reuse of material
Collection	Sporadic and inefficient. Service. is limited to high visibility area, the wealthy and businessmen willing to pay	Improved collection from residential area. Large vehicle fleet and more mechanization.	Collection rate greater than 90% compaction trucks and highly mechanized vehicles are common.
Recycling	Most recycling is through the informal sector and waste picking.	Informal sector still involved some high technology sorting and processing facilities.	Recycle material collection services and high technology sorting and processing facilities. Increasing attention towards long term markets.
Composting	Rarely taken formally even though the waste stream has high percentage of organic contents.	Large composting plants are generally unsuccessful small scale projects are more sustainable.	Becoming more popular at back yard and large scale facilities. Waste stream has less amount of compostible than low and middle income countries.
Incineration	Not common or successful because of high capital percentage of moisture and high percentage of inert.	Some incinerators are used but experiencing financial and operation difficulties. Not as common as high income countries	Prevalent in areas with high land costs most incinerators have some form of environmental controls and some types of energy recovery system
Landfill	Low-technology sites usually open dumping of waste.	Some controlled and sanitary land- fills with some environment controls. Open dumping is still	Sanitary landfills with a combination of liners leachate collection systems and gas collection and treatment

		common.	systems.
Costs	Collection cost represents 80 to 90 percent of municipal solid waste budget. Waste fees are regulated by some local governments but fee collection system is inefficient.	Collection cost 50 to 60 percent of municipal solid waste budget waste fees are regulated by some national and local government. More innovation in fee collection.	Collection cost represents 10% of the budget. Large allocation to intermediate waste treatment facilities.

LITERATURE STUDY: 3

2.3.1 Type of Solid Waste

Solid waste can be classified into different types depending on their source:

1. Household waste as hazardous waste and
2. Biomedical waste or hospital waste as infectious waste.

2.3.2 Municipal Solid Waste

Municipal solid waste consists of household waste, construction and demolition debris, sanitation residue, and waste from streets. This garbage is generated mainly from residential and commercial complexes. With rising urbanization and change in lifestyle and food habits, the amounts of municipal waste has been increasing rapidly and its composition changing.

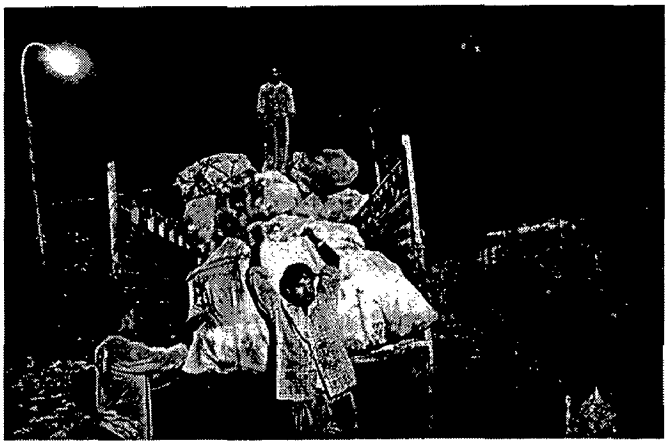


Figure 2.7: Municipal Solid Waste

In 1947, cities and towns in India generated an estimated 6 million tonnes of solid waste; in 1997, it was about 48 million tonnes.

More than 25 percent of the municipal solid waste is not collected at all; 70 percent of the Indian cities lacs adequate capacity to transport it and there are no sanitary landfills to dispose off the waste. The existing landfills are neither well-equipped not well-managed and are not lined properly to protect against contamination of soil and groundwater sources.

Over the last few years the consumer market has grown rapidly leading to products being packed in cans, aluminum foils, plastics and other such non-biodegradable items that cause incalculable harm to the environment. In India, some municipal areas have banned the use of plastics and they seem to have achieved success. For example, today one will not see a single piece of plastic in the entire district of Ladakh where the local authorities imposed a ban on plastics in 1998. Other states should follow the example of this region and ban the use of items that cause harm to the environment. One positive note is that in many large cities, shops have begun packing items in reusable or biodegradable bags. Certain biodegradable items can also be composted and reused. In fact, proper handling of the biodegradable waste will considerably lessen the burden of solid waste that each city has to tackle.

There are different categories of waste generated; each takes its own time to degenerate as illustrated in the table below:

Garbage; The four broad categories	
Organic waste:	Kitchen waste, vegetable flowers, leaves, fruits.
Toxic waste:	Old medicines, paints, chemicals, bulbs, spray cans, fertilizer and pesticide containers, batteries, shoe polish.
Recyclable:	Paper, glass, metals, plastics.
Soiled:	Hospital waste such as cloth soiled with blood and other body fluids.

2.3.3 Hazardous Waste

Industrial and hospital waste is considered hazardous as it may contain toxic substances. Certain types of household wastes are also hazardous. Hazardous wastes could be highly toxic to humans, animals and plants; are corrosive, highly inflammable, or explosive; and react when exposed to certain things e.g. gases. India generates around 7 million tonnes of hazardous wastes every year, most of which is concentrated in four states: Andhra Pradesh, Bihar, Uttar Pradesh and Tamil Nadu.

Household waste that can be categorized as hazardous waste includes old batteries, shoes polish, paint tins, old medicines and medicine bottles.

Figure 2.8: Hazardous Waste

Hospital waste, contaminated by chemicals used in hospital, is considered hazardous. These chemicals include formaldehyde and phenols, which are used as disinfectants and mercury, which is used in thermometers or equipment that measure blood pressure. Most hospitals in India do not have proper disposal facilities for these hazardous wastes.

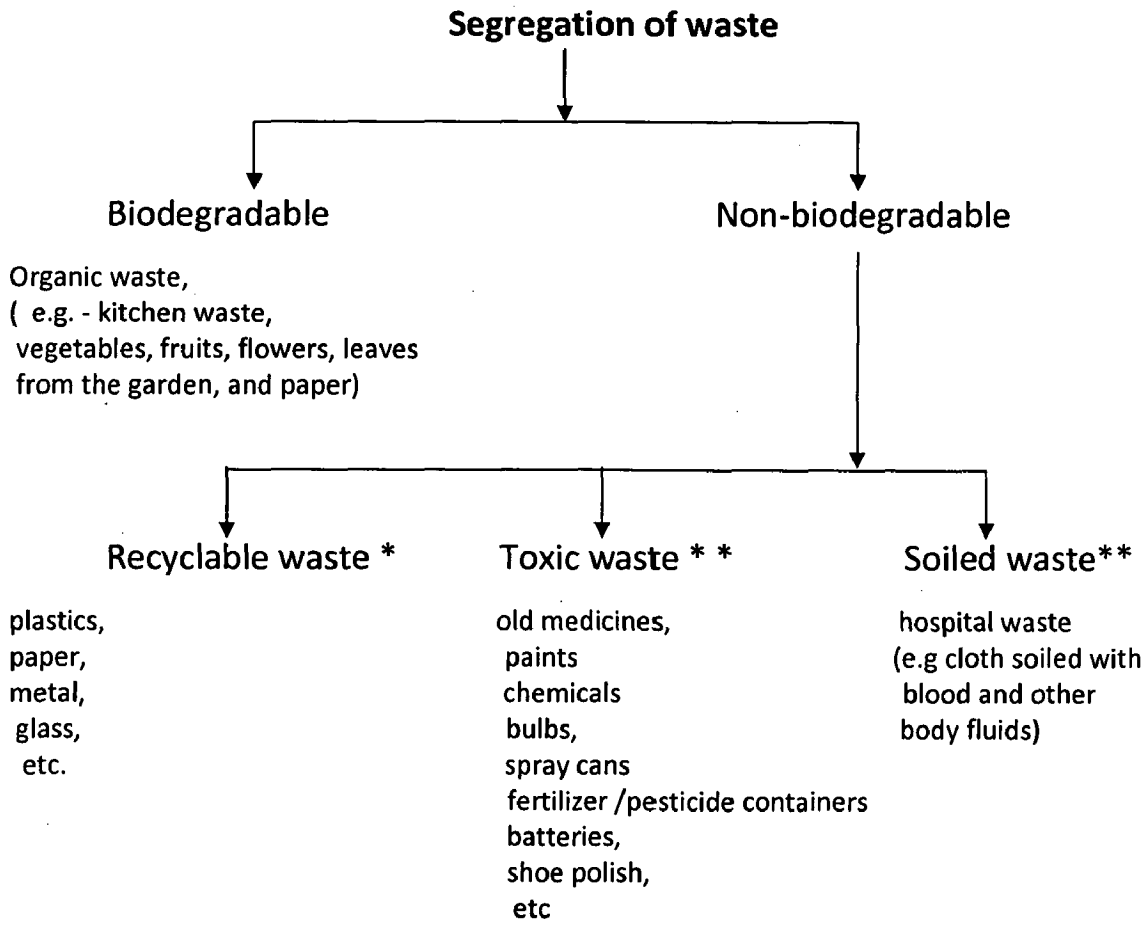
In the industrial sector, the major generators of hazardous waste are the metal, chemical, paper, pesticide, dye, refining and rubber goods industries.

Direct exposure to chemical in hazardous waste such as mercury and cyanide can be fatal.

LITERATURE STUDY: 4

2.4.1 Segregation of Municipal Solid Waste

Municipal waste is being generated in ever increasing volumes in the urban areas. The following schematic diagram shows how municipal solid waste is segregate and where it can be used.



* Though paper is a biodegradable waste, it has been included in recyclable waste (under non Biodegradable waste) as it can be recycled

** Toxic and soiled waste must be disposed off with utmost care.

Source: CPCB report on Management of municipal solid waste.

2.4.2 Segregation

Certain things that are needed around the house are kept aside to be sold to the *kabadiwala* or the man who buys old items. These items are newspapers, used bottles, magazines, carry bags, old exercise books, oilcans, etc. This is one form of segregation, which is done as a routine in all households in India. Separating our waste is essential as the amount of waste being generated today causes immense problem.

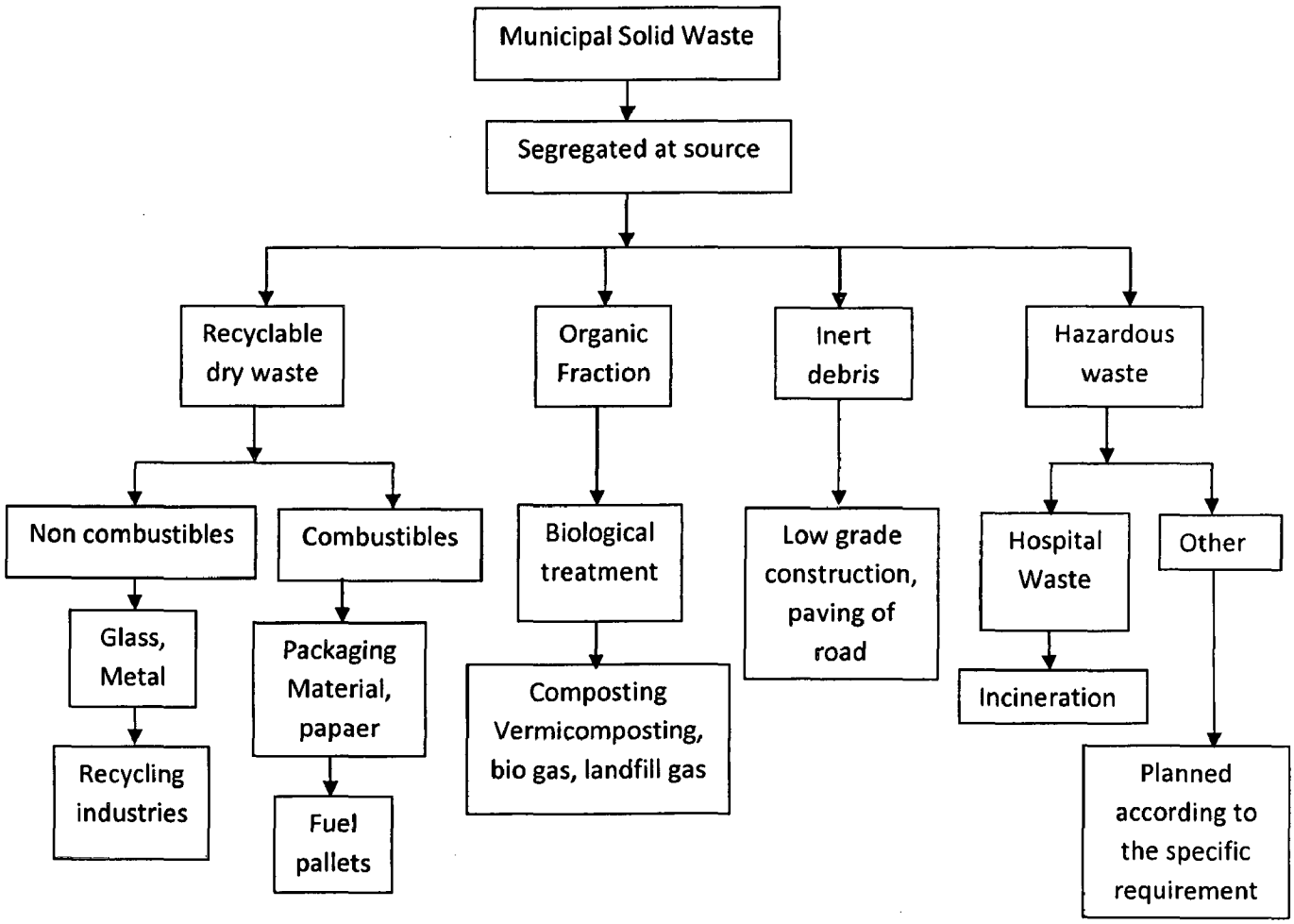


Figure 2.9: Segregation of Municipal Solid Waste

Segregation of municipal solid waste can be easily understood by schematic diagram as shown above.

Certain items are not biodegradable but can be reused or recycled. In fact, it is believed that a larger portion can be recycled, a part of it can be converted to compost and only a smaller portion of it is real waste that has no use and has to be discarded.

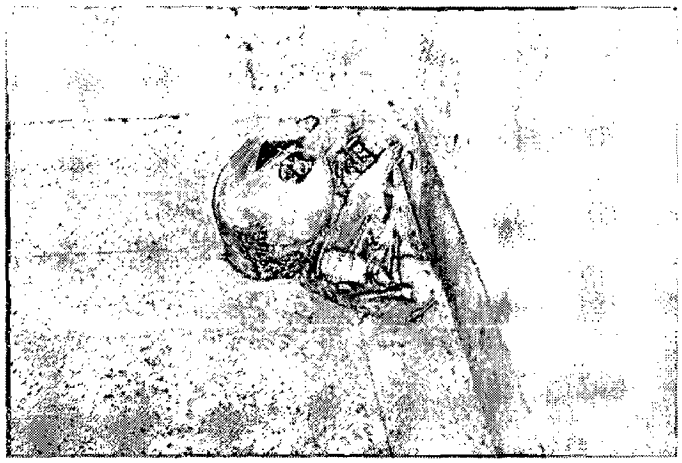


Figure 2.10: Segregation of Household Solid Waste

Household waste should be separated daily into different bags for different categories of waste such as wet and dry waste, which should be disposed off separately. One should also keep a bin for toxic waste such as medicines, batteries, dried paint, old bulbs and shoe polish, etc. Wet waste which consists of leftover foodstuff, vegetable peels, etc should be put in a compost pit and the compost could be used as manure in the garden. Dry waste consisting of aluminum foils, plastics, metal, glass and paper could be recycled.

If we do not dispose off the waste in a more systematic manner, more than 1400 sq. km of land, which is the size of the city of Delhi, would be required in the country by the year 2047 to dispose off vast volumes of the accumulated waste.

Door to door collection of waste is another method of segregation, but it is not a common practice as yet in India except in the metros where some private organizations are doing such work. The rag-picker plays a very important role in the segregation of waste.

It is now becoming more and more essential to look for methods by which the garbage load on the land can be reduced. It has been seen that at present segregation of waste at source level seems to be the best.

A large number of NGOs (non-governmental organizations) are working in the field of solid waste management such as ***Clean Ahmadabad Abhiyan*** in Ahmadabad, ***Waste-Wise*** in Bangalore, ***Mumbai Environment Action Group*** in Mumbai and ***Vatavaran*** and ***Srishti*** in Delhi. They are all successfully creating awareness among the citizens about their rights and responsibilities toward solid waste and the cleanliness of their city. These organizations promote environmental education and awareness in schools and involve communities in the management of solid waste.

LITERATURE STUDY: 5

2.5.1 Treatment and Disposal of Municipal Waste

As cities are growing in size with a rise in population, the amount of waste generated is increasingly becoming unmanageable. The local corporations have adopted different methods for the disposal of waste, such as -- open dumps, landfills, sanitary landfills, and incineration plants. One of the important methods of waste treatment is composting.

2.5.2 Open Dumps

Open dumps refer to uncovered areas that are used to dump solid waste of all kinds. The waste is untreated, uncovered and not segregated. It is a breeding ground for flies, rats and other insects that spread diseases.

Figure 2.11: Open Dumps

The rainwater run-off from these dumps contaminates nearby land and water thereby spreading diseases. In some countries open dumps are being phased out.

2.5.3 Landfills

Landfills are generally located in urban areas where a large amount of waste is generated and has to be dumped in a common place. Unlike an open dump, it is a pit that is dug in the ground. The garbage is dumped and the pit is covered thus preventing breeding of flies and rats. At the end of each day, a layer of soil is scattered on top of it and some mechanism, usually earth-moving equipment is used to compress the garbage which now forms a cell. Thus every day garbage is dumped and becomes a cell. After the landfill is full, the area is covered with a thick layer of mud and the site can thereafter, be developed as a parking lot or a park.

Landfills have many problems. All types of waste are dumped in landfills and when water seeps through them, they get contaminated and in turn pollute the surrounding area. This contamination of ground water and soil through landfills is knows as ***leaching.***

2.5.4 Sanitary Landfills

An alternative to landfills which will solve the problem of leaching to some extent, is a sanitary landfill which is more hygienic and built in a methodical manner. These are lined with materials that are impermeable such as plastics and clay and are also built over impermeable soil. Constructing sanitary landfills is very costly and they are having their own problems. Some authorities claim that often the plastic liner develops cracks as it reacts with various chemical solvents present in the waste.

The rate of decomposition in sanitary landfills is also extremely variable. This can be due to the fact that less oxygen is available as the garbage is compressed very tightly. It has also been observed that some biodegradable materials do not decompose in a landfill. Another major problem is the development of methane gas, which occurs when little oxygen is present, i.e. during anaerobic decomposition. In some countries, the methane being produced from sanitary landfills is tapped and sold as fuel.

2.5.5 Incineration Plants

The process of burning waste in large furnaces is known as incineration. In these plants, the recyclable material is segregated and the rest of the material is burnt. At the end of the process, all that is left behind is ash. During the process, some of the ash floats out with the hot air. This is called fly-ash. Both the fly-ash and the ash that is left in the furnace after burning have high concentrations of dangerous toxins such as dioxins and heavy metals. Disposing off this ash is a problem. The ash that is buried at the landfills, leaches the area and causes severe contamination.

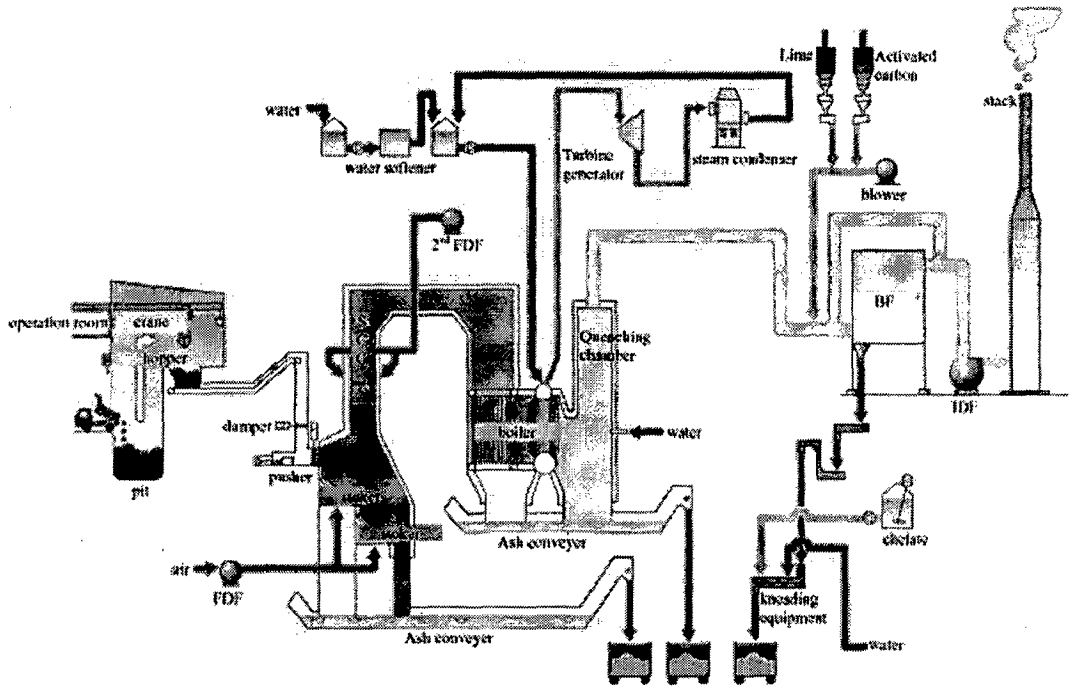


Figure: 2.12 Incineration Plant

Burning garbage is not a clean process as it produces tonnes of toxic ash and pollutes air and water. A large amount of the waste that is burnt here can be recovered and recycled. In fact, at present, incineration is kept as the last resort and is used mainly for treating the infectious waste.

LITERATURE STUDY: 6

2.6.1 Plastics

Plastic, with its exclusive qualities of being light yet strong and economical, has invaded every aspect of our day-to-day life. It has many advantages; it is durable, light, easy to mould and can be adapted to different user requirements. Once hailed as a 'wonder material', plastic is now a serious worldwide environmental and health concern, essentially due to its non-biodegradable nature.

Figure: 2.13 Say No to Plastic Bags

In India, the plastic industry is growing phenomenally. Plastics have use in all sectors of economy - infrastructure, construction, agriculture, consumer goods, telecommunication and packaging. But the good news is that along with a growth in the use, a country-wide network for collection of plastic waste through rag-pickers, waste collectors and waste dealers and recycling enterprises has sprung all over the country over the last decade or so. More than 50 percent of the plastic waste generated in the country is recycled and used in the manufacture of various plastic products.

Conventional plastics have been associated with reproductive problems in both wildlife and humans. Studies have shown a decline in human sperm count and quality, genital abnormalities and a rise in the incidence of breast cancer. Dioxin, a highly carcinogenic and toxic by- product of the manufacturing process of plastics, is one of the chemicals believed to pass on through breast milk to the nursing infant. Burning of plastics, especially PVC, releases this dioxin and also furan into the atmosphere. Thus conventional plastics, right from their manufacture to their disposal, are a major problem to the environment.

Plastics are so versatile in use that their impacts on the environment are extremely wide ranging. Careless disposal of plastic bags chokes the drains, blocks the porosity of the soil and causes problem for ground water recharge. Plastic disturb the microbe activity, and once ingested, can kill animals. Plastic bags can also contaminate foodstuffs due to leaching of toxic dyes and transfer pathogens. In fact, major portion of the plastic bags i.e. approximately 60 to 80 percent of the plastic waste generated in India, is collected and segregated to be recycled. The rest remains strewn on the ground, littered around in open drains, or in unmanaged garbage dumps. Though only a small percentage lies strewn, it is this portion that is of concern as it causes extensive damage to the environment.

Source of generation of waste plastics

Household	Carry bags, Bottles, Containers, Trash bags.
Health and Medicare	Disposable syringes, Glucose bottles, Blood and uro bags,, Intravenous tubes Catheters, Surgical gloves.
Hotel and Catering	Packaging items, Mineral water bottles, Plastic plates, glasses, Spoons.
Air/Rail Travel	Mineral water bottles, Plastic plates, glasses, Spoons, Plastic bags.

The plastic industry in the developed world has realized the need of environmentally acceptable modes for recycling plastic wastes and has set out targets and missions. Prominent among such missions are the Plastic Waste Management Institute in Japan, the European Centre for Plastics in Environment, and the Plastic Waste Management Task Force in Malaysia. Manufacturers, civic authorities, environmentalists and the public have begun to acknowledge the need for plastics to conform to certain guidelines / standards and code of conduct for its use.

Designing eco-friendly and biodegradable plastics are the need of the hour. Though partially biodegradable plastics have been developed and used, completely biodegradable plastics based on renewable starch rather than petrochemicals have only recently been developed and are in the early stages of commercialization.

Source: www.plasticsresources.com/plastics101/index.html

LITERATURE STUDY: 7

2.7.1 The Role of the Rag-picker

Rag-pickers are the people who are actually going through the garbage bins to pick out the 'rags'. These rag-pickers -- women, children and men from the lowest rung in the society -- are a common sight in most cities and towns around the country. Rage-picking is considered the most menial of all activities and it is people who have no other alternative that are generally driven to it. Rag-pickers contribute a great deal to waste management as they scavenge the recyclable matter thereby saving the municipality of the cost and time of collecting and transporting this to the dumps.

Figure: 2.14 The Rag-Pickers

The rag-picker has a special role to play in the segregation of waste in India. He is one of the focal points for the recycling of waste. He is the person who, in spite of all the dangers that he faces, goes on relentlessly picking through the garbage bin, looking for waste that could be useful to him. He sells all the material he picks to the retailers and whole-sellers and they in turn sell it to the industry that uses this waste matter as raw material. The main items of collection by the rag-pickers are plastics, paper, bottles and cans.

NGOs like ***Vatavaran*** in Delhi, ***Centre for Environmental Education*** (***CEE***) in Bangalore and ***Srimati Nathibai Damodar Thackersey*** (***SNDT***) ***Women's University*** in Pune have highlighted the cause of the rag-pickers and have taken initiative to improve their lot. Although these efforts are at a local level, they are invaluable. In Bangalore, the Waste-Wise project was initiated in 1990 with the aim of improving the conditions of the rag-pickers and at the same time benefiting the society and the local authorities.

Self Employees' Women Association (***SEWA***) in Ahmadabad has formed a rag-pickers' cooperative and over the years, has helped the women to organize themselves better and collect waste that is recyclable.

Rag-pickers are well-coordinated in their method of working. Among themselves, they have a good understanding for operating by area, each group specific items from the bins. It has been observed that more and more women and children are getting involved in the business of rag- picking. This is a matter of concern as these children, who should be spending their time in schools either studying or playing, are instead putting themselves at risks by handling waste. While picking through waste, the rag picker puts himself at a great risk and is always prone to disease as the waste that he rummages through, can be infected.

We can indirectly help the rag-picker by carefully segregating the waste that is generated at our homes, thereby facilitating his search for materials that are useful to him. He will not have to scavenge in the bins for long hours.

2.7.2 Recycle of Wastes

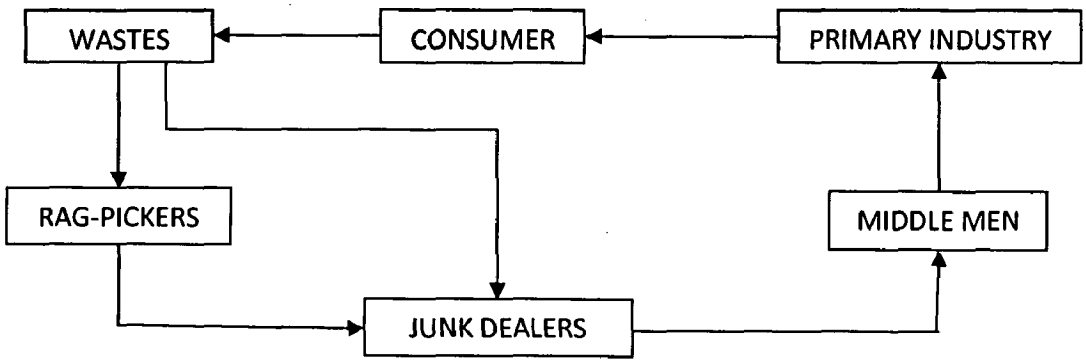
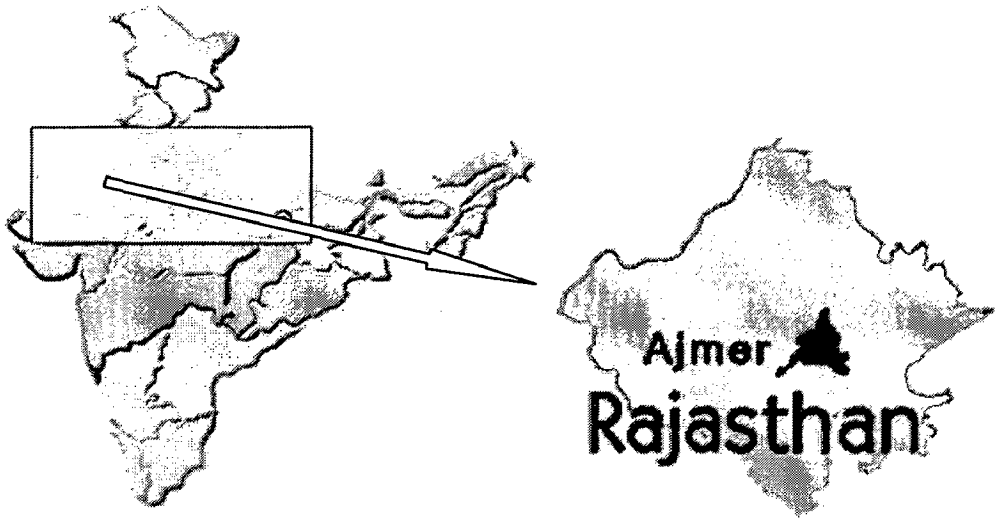


Figure: 2.15 Recycle of Wastes

Sources: - www.dep.state.pa.us/see%26hear/interative/2school.htm

CASE STUDY

3. 1 AJMER



Map 3.1

3.1.1 Introduction

Ajmer, situated in the green oasis wrapped in the barren hills, has been a witness to an interesting past. The city was founded by Raja Ajay Pal Chauhan in the 7th Century A.D. and continued to be a major center of the Chauhan power till 1193 A.D. when Prithviraj Chauhan lost it to Mohammed Ghauri. Since then Ajmer became home to many dynasties which came and left leaving behind indelible marks of their culture and traditions on the city's history converting it to an amalgam of various cultures and blend of Hinduism and Islam.

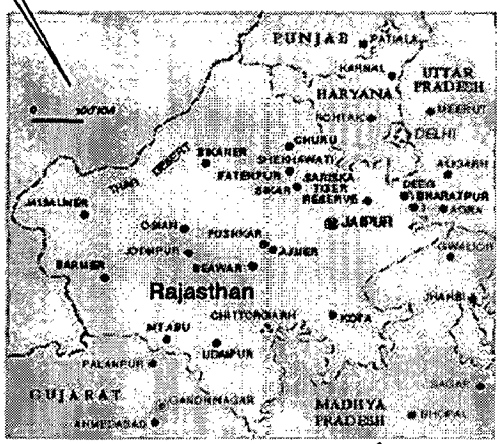
Today, Ajmer is a popular pilgrimage center for Hindus as well as Muslims. Especially famous is the Dargah Sharif, tomb of the Sufi saint Khwaja Moinuddin Chisti, which is equally revered by Hindus and Muslims.

Figure 3.1: Dargah Sharif , Ajmer

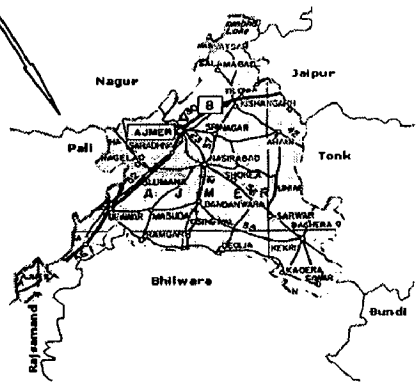
Ajmer is also the base for visiting Pushkar (11 km.) the abode of Lord Brahma lying to its west with a temple and a picturesque lake. The Pushkar dake is a sacred spot for Hindus. During the month of Kartik (October/November) devotees throng in large numbers here to take a holy dip in the sacred lake.

3.1.2 Location

India



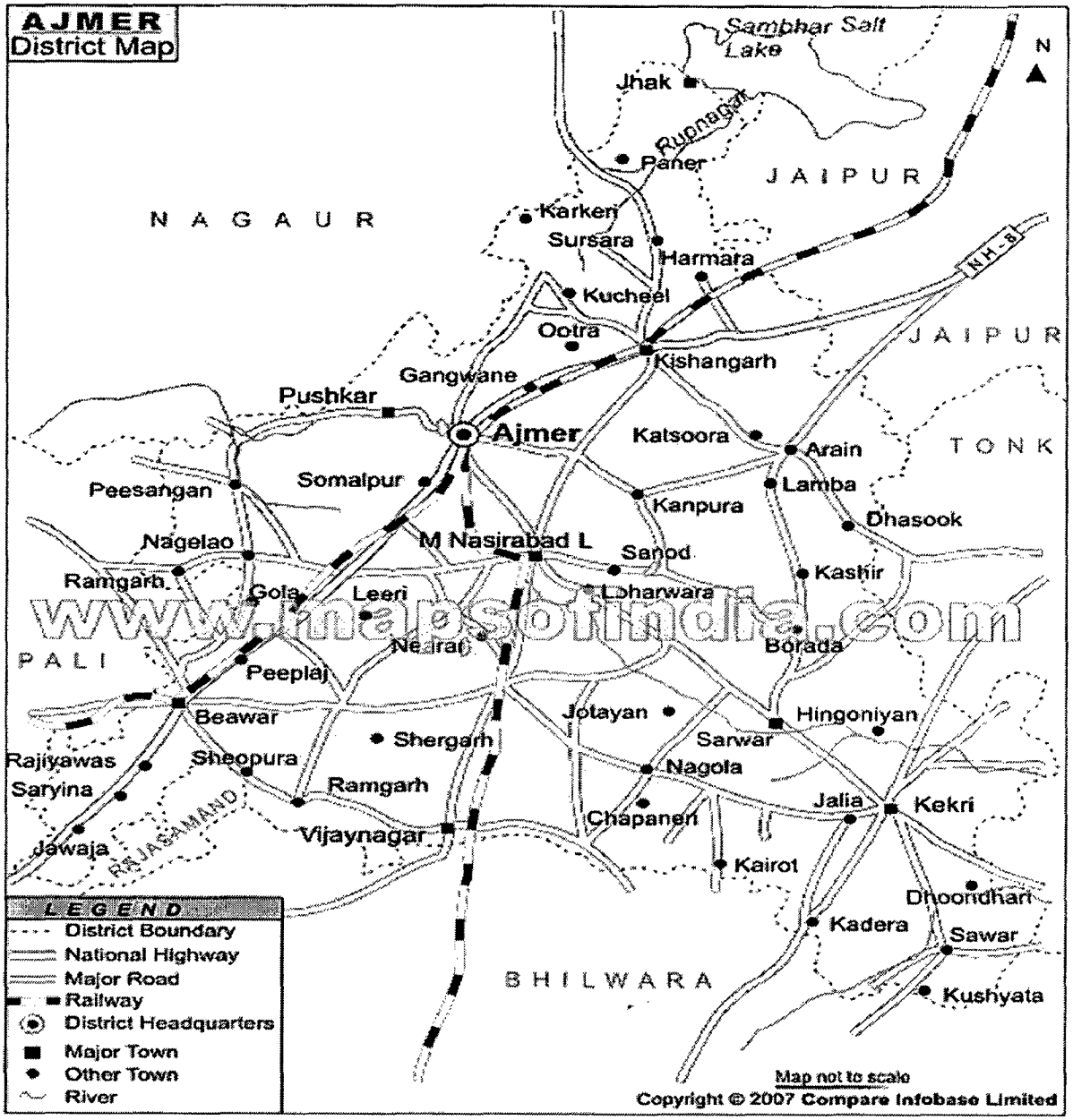
Rajasthan



Disrict Ajmer

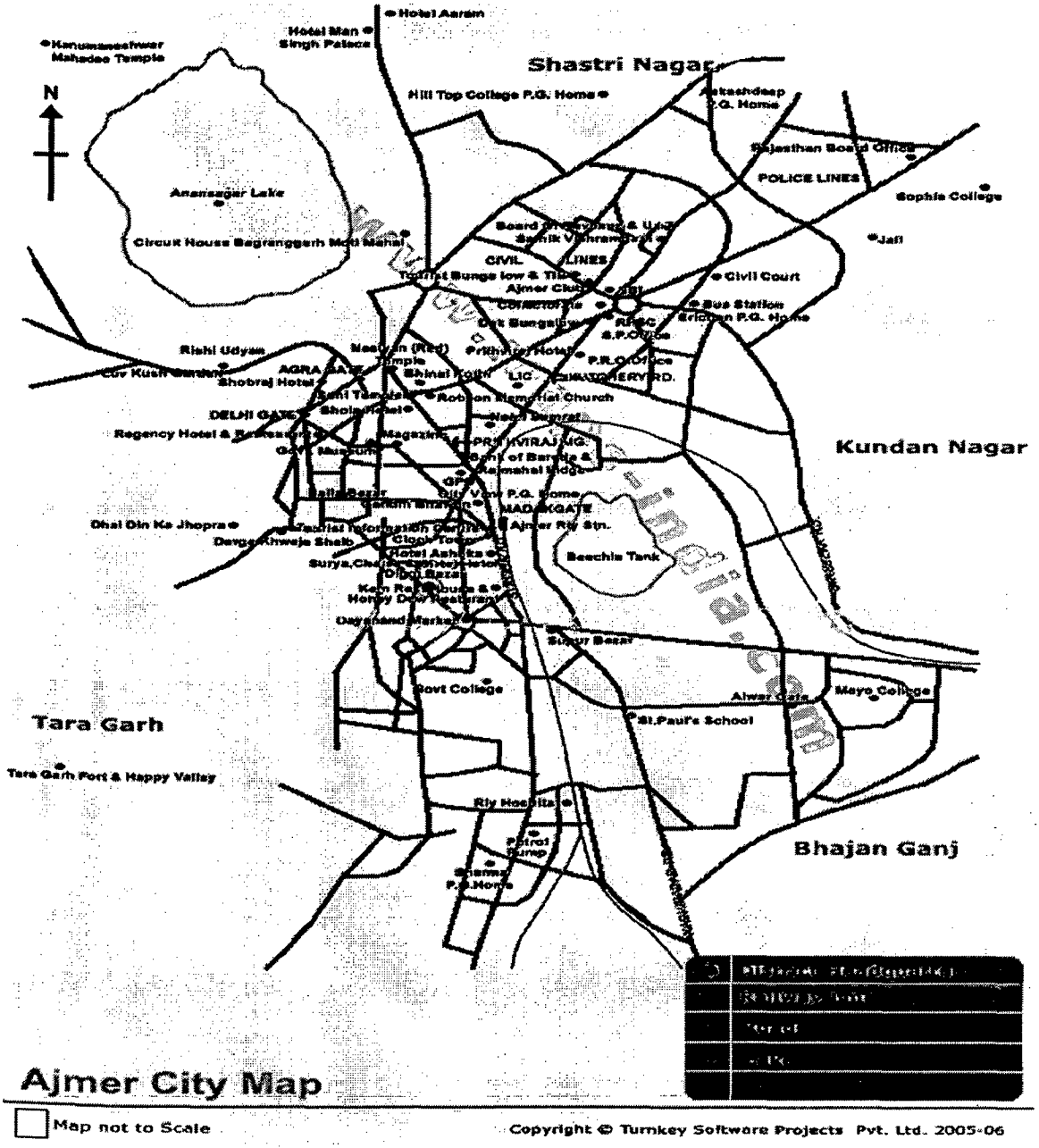
Location of Ajmer, Map 3.2

(a) District Map of Ajmer



Map 3.3
District map of Ajmer

(b) City Map of Ajmer



Map 3.4
City map of Ajmer

3.1.3 History of Ajmer

Historically, Ajmer always had great strategic importance and was sacked by Mahumud of Ghazni on one of his periodic forays from Afghanistan. Later it became a favorite residence of the great Moghuls. One of the first contacts between the Moghuls and the British occurred in Ajmer when Sir Thomas Roe met with Emperor Jahangir here in 1616. The city was subsequently taken by the Scindias and in 1818 it was handed over to the British, becoming one of the few places in Rajasthan controlled directly by British rather than being part of a princely state.

3.1.4 Characterization and Chemical Analysis of Solid Wastes of Ajmer city

(a) Introduction

Solid wastes are all the wastes from human and animal activities that are normally solid and that are discarded as useless or unwanted. The discarded materials have been termed as "Solid Waste" or "Refuse" (The Expert Committee, CPHEEO, 2000).

Thus the solid waste includes all kinds of solid and semi-solid waste products e.g. ash, garbage, house sweepings, street sweepings, dead animals etc. The proper collection, transportation and subsequent disposal with a minimum nuisance have assumed great importance in the modem day community environmental sanitation programmes. Careless handling of refuse attracts insects, rats and rodents besides providing breeding places for flies and mosquitoes and the risk of spread of hazardous communicable diseases.

The city of Ajmer is located close to Jaipur, the capital of Rajasthan and is located, in the semi arid region of Rajasthan. Therefore it is subjected to extreme conditions of weather. The method of open dumping for the disposal of solid wastes has been practised in the city since its inception. During the last decade the population of the city has increased by 21.71 % while the quantity of solid waste generated has increased by about 100%. Although the quantity of solid waste generated has approximately doubled and the city has also expanded towards the site of disposals yet the same method of dumping of solid waste disposal continues in practice since independence. (Indian Census, 2001).

The quantity of daily solid waste generated from the Municipal Council of Ajmer is 220 to 250 tonnes and the per capita waste generation rate is 0.45 to 0.51 kg/day.

In the light of the problems generated by this solid waste component which contains organic (kitchen waste) and inorganic waste (paper, plastic, metal, leather, glass, dust, textile, rubber etc.) a study entitled "Characterisation and Chemical Analysis of Solid Wastes of Ajmer City (Rajasthan, India) is presented in this paper.

(b) Materials and Methods

The Ajmer city is divided into nine municipal circles and has fifty five municipal wards and 339 waste collection sites. The number of waste collection sites in each of municipal wards vary from 6 to 39 (Municipal Council Ajmer, 2002).

In order to study the representative waste samples from each municipal ward, samples from each were taken (10 sites) on the Second Tuesday of every month. Ten kg of waste sample was taken for chemical analysis.

For determining the percentage composition of the waste, quartering method of sampling was followed. The waste components were sorted out on white sorting table and each component was weighed again to ascertain the percentage composition of individual waste constituent.

(c) Chemical Analysis of Waste Material

The following parameters were analyzed:

1. pH (by pH meter)
2. Electrical conductivity (by conductivity meter)

An analysis of solid wastes collected from the various collection sites revealed the following facts:

The organic content of solid waste was 25.48% which was high due to the practice of eating fresh vegetables and fruits.

The paper content of refuse was 4.88% and this was observed to increase with increase in the size of the city. The main components of paper content were mainly newspaper, toffee wrappers, postage, copies and books. All the material was

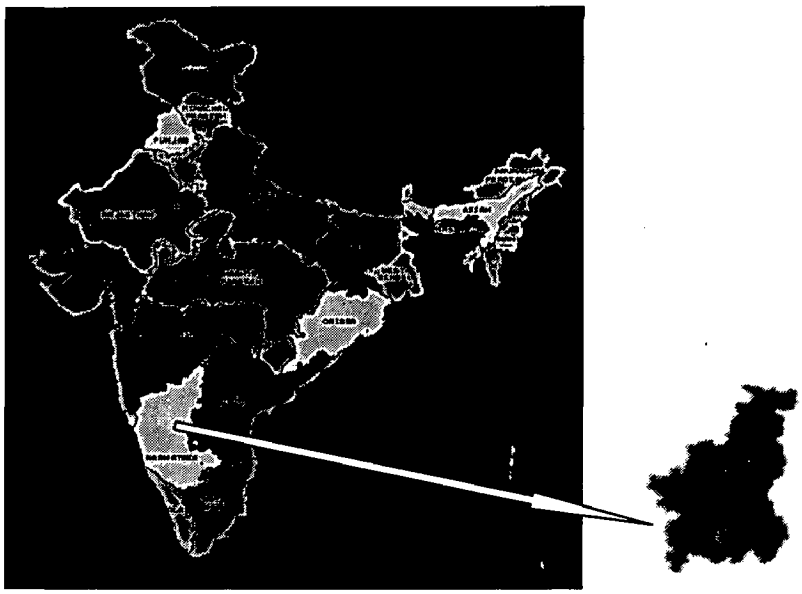
found to be biodegradable in nature which would not create environmental hazards. Glass content of solid waste was 0.57% which was quite low. The low glass content was essentially due to its reclamation at source.

The plastic content was 6.08%. Higher plastic content poses increased problems of disposal. The main components of plastic waste were buckets, mugs shampoo bottles, ghee containers, ice cream cups, combs, plastic pens and poly bags. Among these component, poly bags alone constituted about two third of the total plastic waste. The contents of mud and ash were 57.19% due to the common practice of disposing of street sweepings in dust-bins.

The wide-spread use of mud powder as construction material and lack of concrete surface increase the density which was observed to be 168. 45 kg/m^3.

Moisture content was 19.34% which showed poor solid waste management practices.

3.2. MYSORE



Karnataka (Mysore)

Map 3.5

3.2.1 Introduction

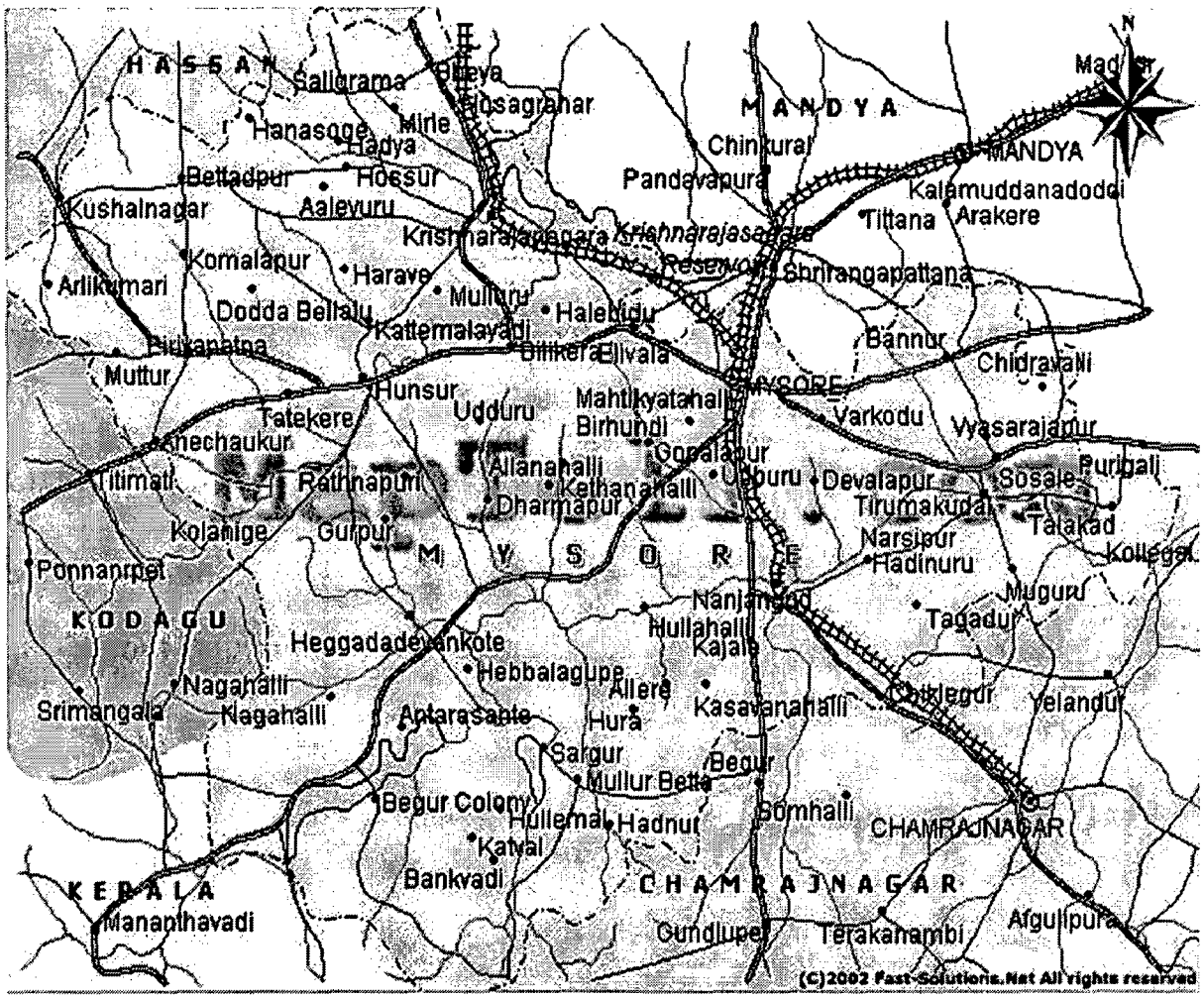
Mysore is the cultural capital of Karnataka state. The palaces which were primarily built for the kings and their families were not only for pleasure but also glowed with artistic beauty, hence they attract visitors from all the parts of the world.

Some of the palaces have now become attraction for tourists, some of them now house government offices while some others have been transformed into hotels, and university offices. The famous ones are Mysore Palace, Jaganmohan Palace, Jayalakshmi Vilasa and Lalitha Mahal.

Figure 3.2: The Mysore Palace

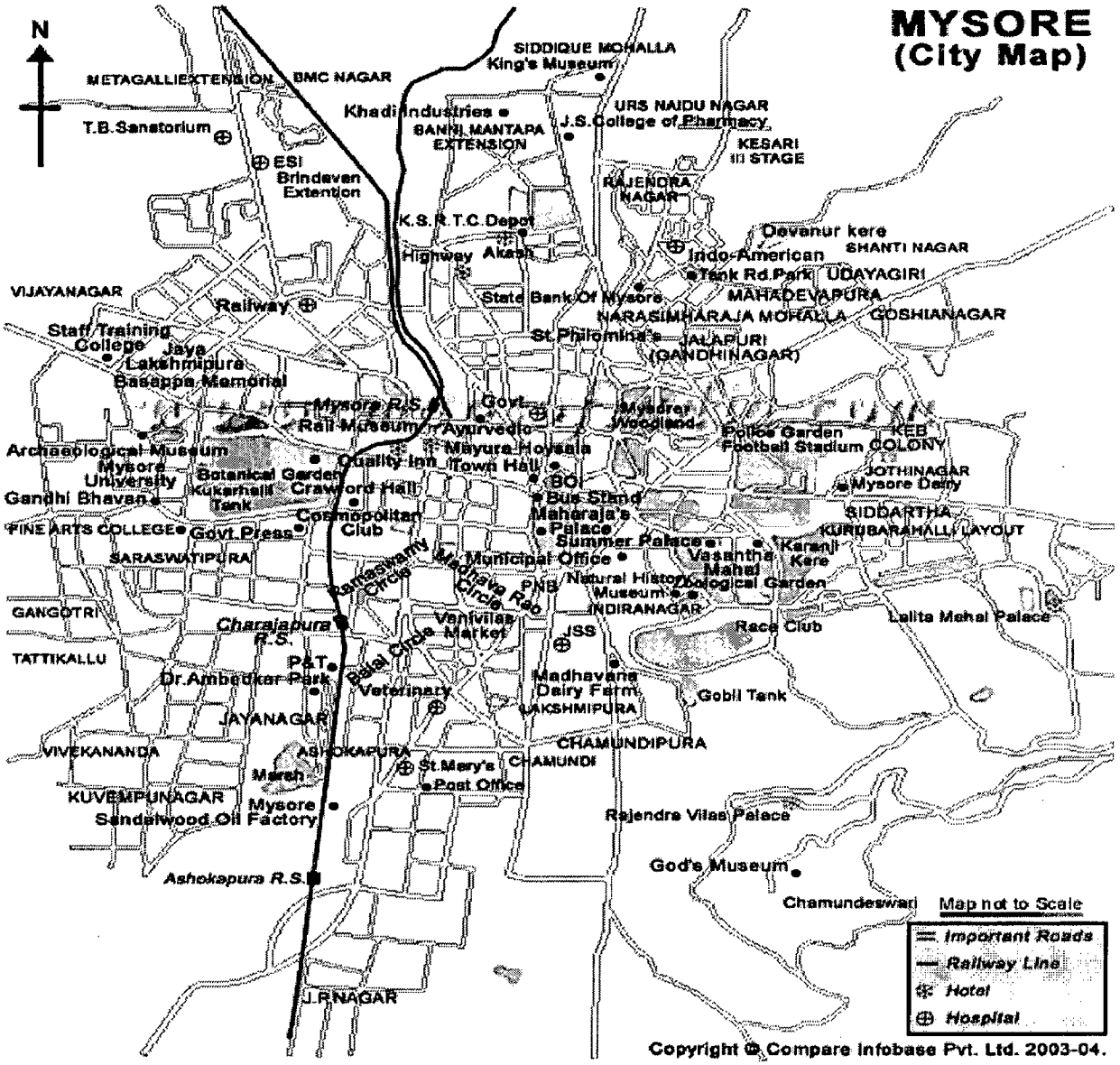
3.2.2 Location

(a) District Map of Mysore



Map 3.6
District Map of Mysore

(b) City Map of Mysore



Map 3.7
City Map of Mysore

3.2.3 Solid Waste Management of Mysore City

(a) Introduction

Solid wastes are the wastes arising from human and animal activities that are normally solid and that are discarded as useless or unwanted . Both technical processes and consumptive processes result in formation of solid waste. The quantity of solid waste generated in urban area, ranges from 0.3-0.5 kg/capita/day, depending upon the life style of people

Solid waste is generated in the beginning, with the recovery of raw materials and thereafter at every step in the technological processes as the raw material is converted to a product for consumption. In addition, other processes such as street cleaning, park cleaning, waste-water treatment, air pollution control measures, etc. also produce solid wastes in urban areas.

To plan effectively for solid waste management, information and data on the expected (future) composition of the solid waste are important. Solid waste can be of several types depending upon its Source of generation and it comprises of dust, food wastes, packing in the form of paper, metals, plastics, glass, worn-out clothings and furniture, garden wastes, wastes form construction and demolition processes, dead bodies of animals and plants, pathological wastes, hazardous wastes, radioactive wastes and agricultural wastes. Refuse characteristics have been known to vary depending upon the degree of industrialization, standards of living and dietary habits of the community. Also wastes can be characterized as

1) kitchen wastes like non-vegetarian waste, fruit waste, vegetable waste and left over kitchen waste,
2) animal wastes and
3) Miscellaneous waste like paper, metal, plastics, cloth, leather and glass

The waste treatment and disposal aspects include many methods among which the sanitary landfilling, incineration, composting and anaerobic decomposition are the most important methods. Municipal solid waste constituents have different

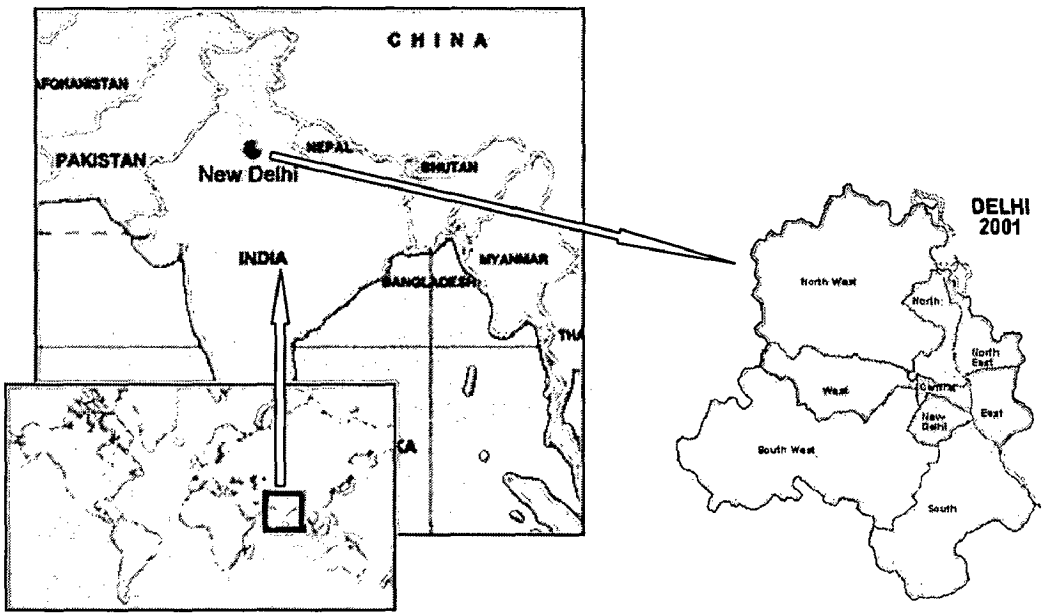
sizes according to which they can be separated. Ferrous metals are separated magnetically and other putrescent materials are eliminated using thrower separator

Recycling is collecting, reprocessing, marketing and using materials that were once considered trash. In other words, it is to reclaim a substance for further use. The constituents of domestic wastes are commonly extracted for industrial use such as paper for re-pulping, textiles for paper making, machinery wipers, etc:, metals and glass for re-melting, rubber for downgraded use and plastics for production of inferior grade plastics . Recycling of these materials effectively reduces the waste load on the disposal sites and hence a lesser area of landfill is required for disposal

(b) Materials and Methodology

Information on the composition of solid wastes is important in evaluating alternative equipment needs, systems and management programs and plans. Information and data on the physical composition of solid wastes are imponant in the selection and operation of equipment and facilities, in assessing 'recovery', and in the analysis and design of disposal facilities.

3.3 DELHI



Delhi, Map 3.8

3.3.1 Introduction

Area: 1,483 sq km,

Population: 1,38, 50,507

Population Density: 9,340 persons/sq km.

Located on the banks of the river Yamuna in the national capital territory of India, Delhi has been continuously inhabited since at least the 6th century BC, according to archaeological evidence. After the rise of the Delhi Sultanate, Delhi emerged as a major political, cultural and commercial city along the trade routes between the northwest India and the Indo-Gangetic plains. It is the site of many ancient and medieval monuments, archaeological sites and remains. In 1639, Mughal emperor Shahjahan built a new walled city in Delhi which served as the capital of the Mughal Empire from 1649 to 1857.

After the British East India Company gained control of much of India during the 18th and 19th centuries, Calcutta became the capital both under Company rule

and under the British Raj, until George V announced in 1911 that it was to move back to Delhi.

A new capital city, New Delhi, was built to the south of the old city during the 1920s.

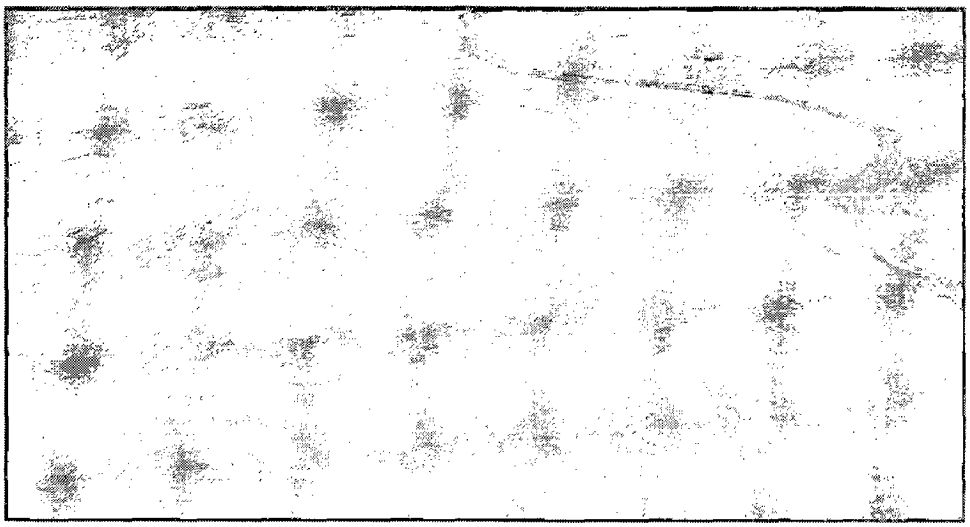
When India gained independence from the British rule in 1947, New Delhi was declared its capital and seat of government. As such, New Delhi houses important offices of the federal government, including the Parliament of India.

Owing to the migration of people from across the country, Delhi has grown to be a cosmopolitan metropolis. Its rapid development and urbanisation, coupled with the relatively high average income of its population, has transformed Delhi. Today, Delhi is a major cultural, political, and commercial center of India.

3.3.2 Location

Map 3.9
Delhi satellite map

Map 3.10
A Panoramic view of Delhi

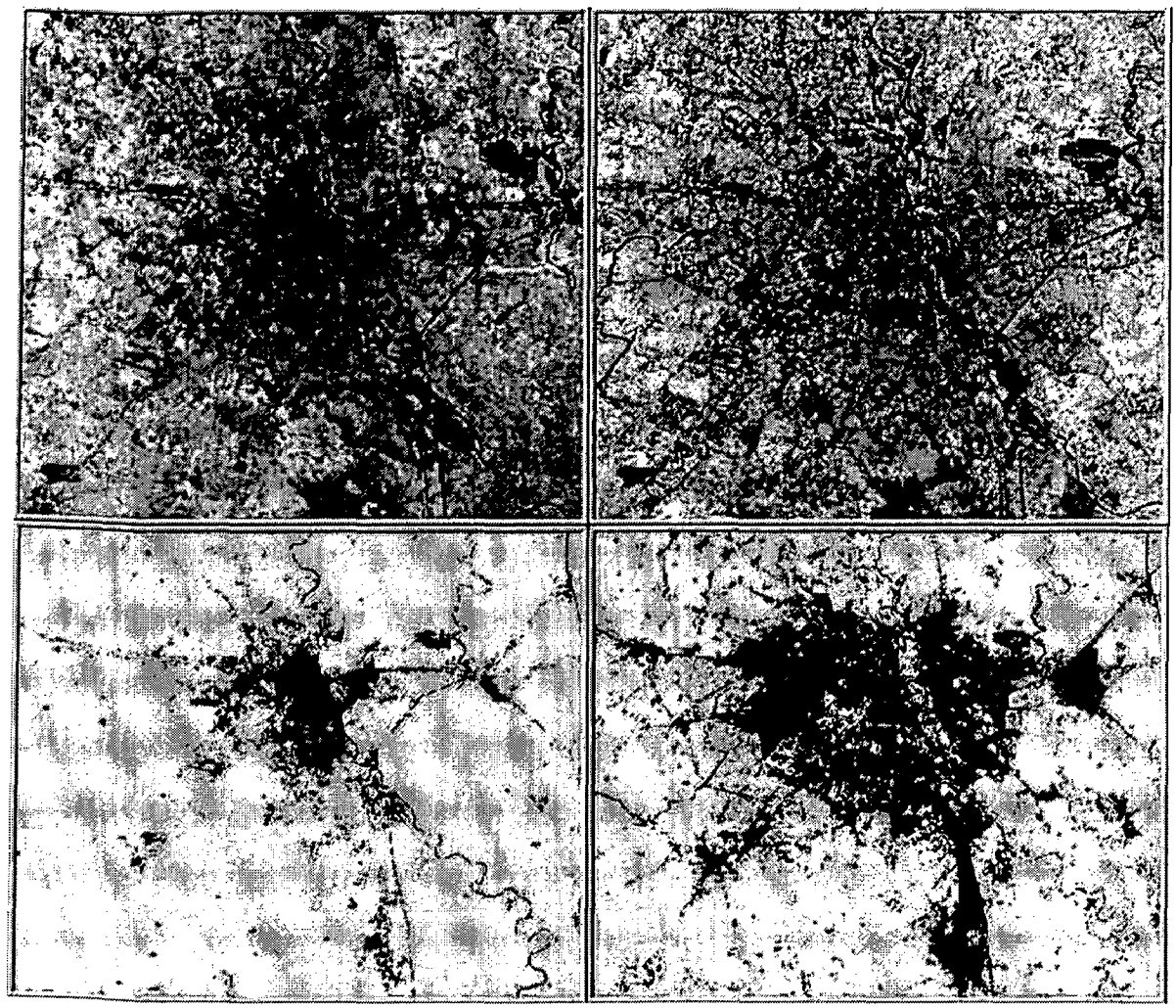


Map 3.11
Google Map of Delhi

Delhi is located at 28°37'N to 77°14'E & 28.61°N to 77.23°E, and lies in northern India. It borders the Indian states of Uttar Pradesh on East and Haryana on West, North and South. Delhi lies almost entirely in the Gangetic plains. Two prominent features of the geography of Delhi are the Yamuna flood plain and the Delhi ridge. The low-lying Yamuna flood plains provide fertile alluvial soil suitable for agriculture. However, these plains are prone to recurrent floods. Reaching up to a height of 318 m (1,043 ft), the ridge forms the most dominating feature in this

region. It originates from the Aravalli Range in the south and encircles the west, northeast and northwest parts of the city. Yamuna, considered a sacred river by Hindus, is the only major river flowing through Delhi. Most of the city, including New Delhi, lies west of the river. East of the river is the urban area of Shahdara, Mayur Vihar, IP Extension and Vasundhara Enclave. Delhi falls under seismic zone-IV, making it vulnerable to major earthquakes.

3.3.3 Delhi Urban Growth



Map 3.12
Delhi Urban Growth

Colour Key of Satellite Maps: - (Red-Urban, Brown-Agriculture, Green-Forest, Yellow -Grass Land, Pink-Wet Land, Blue-Water and White-Barren)

3.3.4 Public Private Partnership for Solid Waste Management In Delhi: a Case Study

(a) Introduction

Solid waste management in Delhi has been a very poorly planned affair with onus on simply transporting the mixed waste by trucks and disposing it in sanitary landfills (SLF). The Municipal Corporation of Delhi (MCD)has been spending between Rs.300 and 400 crores every year on sanitation and cleanliness and the sum is likely to increase sharply in the coming years.

Complete negligence of waste minimization and recycling over the years gave way to a whole lot of problems with disposal emerging as a major one.

--The Hindu

Since 1975,20 SLFs have been created of which 15 are exhausted, while 2 are suspended. Only 3 are operational at Bhalaswa, Ghazipur, and Okhla, and even these are close to exhaustion.

With Commonwealth Games round the comer, Delhi government, in its attempt to overcome the grim scenario, signed agreements with three private companies for collection, segregation, transportation and disposal of municipal solid waste in six zones on January 31, 2005 (The Hindu). Aimed at increasing efficiency and effectiveness of its waste management activities, MCD planned this public private partnership project in six zones -- City, South, West, Central, Karol Bagh and Sadar Paharganj. The three agencies with which the civic body signed the 'concession agreement' for the project are ***Delhi Waste Management Pvt Ltd*** for South, Central, and City zones, Noida-based ***Ag Enviro Infra Projects (P) Ltd*** for Karol Bagh and Sadar Paharganj zones and Delhi-based ***Metro Waste Handling (P) Ltd. (MWH)*** for West zone. The project proposed to be implemented in phases went fully operational in June 2005. The private companies were allotted a concession period of 9 years inclusive of the implementation period of 12 months from the date of signing the agreement. The agreement also contained a performance evaluation and monitoring mechanism where the monitoring of the

project was to be carried out by an 'independent engineer' appointed by mutual consent of the corporation and the companies.

MSV Pvt Ltd was appointed as the 'independent engineer' to monitor the project. In this study we have monitored the working and operation of Delhi- based ***Metro Waste Handling Pvt Ltd,*** which is handling the collection, segregation and transportation of the solid waste in the West zone. The study shows the paradigm shift that has been brought about in the sphere of solid waste management with the advent of public private partnership. It specially focusses on the waste segregation which was totally neglected during the MCD regime.

(b) The West Zone

The west zone of Delhi is, indeed, a true representative of the concrete jungle, an area of approx. 79.75 sq km having a residential population of 15.8 lacs. The municipal solid waste generated in its 16 wards (of which the whole zone comprises of), is well above 500 metric tonnes to 1000 metric tonnes per day.

(c) The Operation Team

The whole task of collection, segregation and transportation is given shape by a team of field supervisors 45 in number, office/technical staff 42 in number, drivers 50 in number, helpers 60 in number and *dhalao* workers 500 in number.

All the 16 wards have been divided into 4 sets of 4 wards each and have been put under the governance of a team leader. Under every team leader, there is a set of field supervisors who are responsible for the following:

- Familiarizing with the assigned area (ward)
- Keeping a track of daily waste collection
- Optimizing the number of *dhalao* workers and maximizing their productivity by assigning them adequate responsibilities
- Visiting the *dhalaos* within his scope of vigilance at least twice a day
- Maintaining vehicle time and route plan

- Ensuring that the *dhalao* workers are well protected and *dhalaos* are thoroughly disinfected
- Ensuring that their respective staff (helpers, drivers, *dhalao* workers) are punctual and are following adequate safety and hygiene norms
- Identification of critical points under his area, where garbage is being dumped or if there is a lack of a *dhalao,* placing of adequate number of bins in those critical areas
- Keeping liaison with local residents, residential welfare associations, councilors, MCD officials and to work in close co-ordination with them.

'Dhalao workers' come next to the 'field supervisors' in the organ ization hierarchy. Number of *dhalao* workers recruited at a particular *dhalao* depends upon the size of the *dhalao* and the load received by it. Optimization of *dhalao* workers at *dhalaos* in an area is done by the field supervisor. However, on an average, 3 *dhalao* workers look after the maintenance of one *dhalao.* They are responsible for receiving the waste from the neighborhood directly in the *dhalaos* and from the bins that are placed in the area surrounding the *dhalao.*

3.3.5 Material Cycle

Every material (matter / energy) is recycled in nature based on the two Laws of Thermodynamics:

1. *Energy/matter is transferred from one form to another form but is never being created or destroyed.*
2. *No processes involving an energy/matter transformation occur unless there is a degradation of energy from a concentrated form into a dispersed from.*

3.3.6 Household Material Cycle

Household waste (matter) cycle comprises of solid waste and liquid waste.

3.3.7 Composition of Household Solid Waste

The composition of garbage in a house contains 25-30% of recyclable material and is about 70-75% compostable material.

Description	Percentage by weight
Vegetable leaves	50.0%
Glass	1.0%
Paper	10.0%
Plastic	5.0%
Glass/ceramics	2.0%
Metal	2.0%
Stones/ashes	15.0 %
Miscellaneous	15.0%

3.3.8 Composition of Municipal Solid Waste at City Level

The municipal solid waste generation of New Delhi is 6,000 TPD or 0.475 kg/day/person. The composition of garbage in a city indicates lower organic matter and high ash or dust contents.

It has been estimated that recyclable content in solid waste varies from 13 to 20 percent. The compostable material in the solid waste is about 80-85%.

3.3.9 A typical composition of municipal solid waste it is given below

Description	Percentage by weight
Vegetable leaves	40.15%
Glass	3.80%
Paper	0.81%
Plastic	0.62%
Glass/ceramics	0.44%
Metal	0.64%
Stones/ashes	41.81%
Miscellaneous	11.73%

3.3. 10 Cycle of Household Solid Waste

It comprises of Collection, Transportation and Disposal.

Collection

Major saleable portion is segregated at house level itself, and then remaining saleable material is collected by the rag-pickers at various levels of transportation.

Transportation

Waste at first level is collected by the sweepers and they store the waste at dustbins or *dhalaos** from there the waste is carried over by trucks to disposable sites.

Disposal

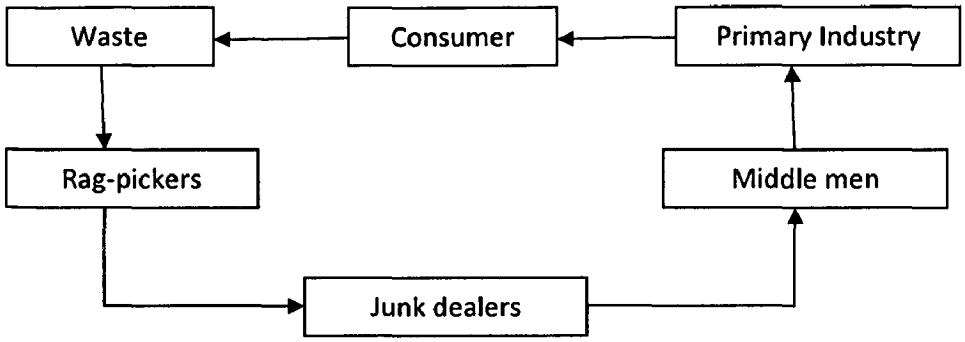
Waste is disposed at landfills.

* Temporary storage sites for municipal waste

Fig.-1 Cycle of decomposable waste

When landfills are full, the sites are used for planting the trees.

Fig.-2 Cycle of recyclable waste



3.3.11 Steps Involved in the Process Prior to Recycling:

1. Collection of waste at door steps, commercial places and from other placements.
2. Collection of waste from community dumps.
3. Collection/picking up of wastes from final disposal sites.

Survey reveals that about 15 to 20 percent of the waste is recycled.

The various types of waste and their cycles to produce different products are discussed below:

Plastic Waste

Fig. 3 Polythene

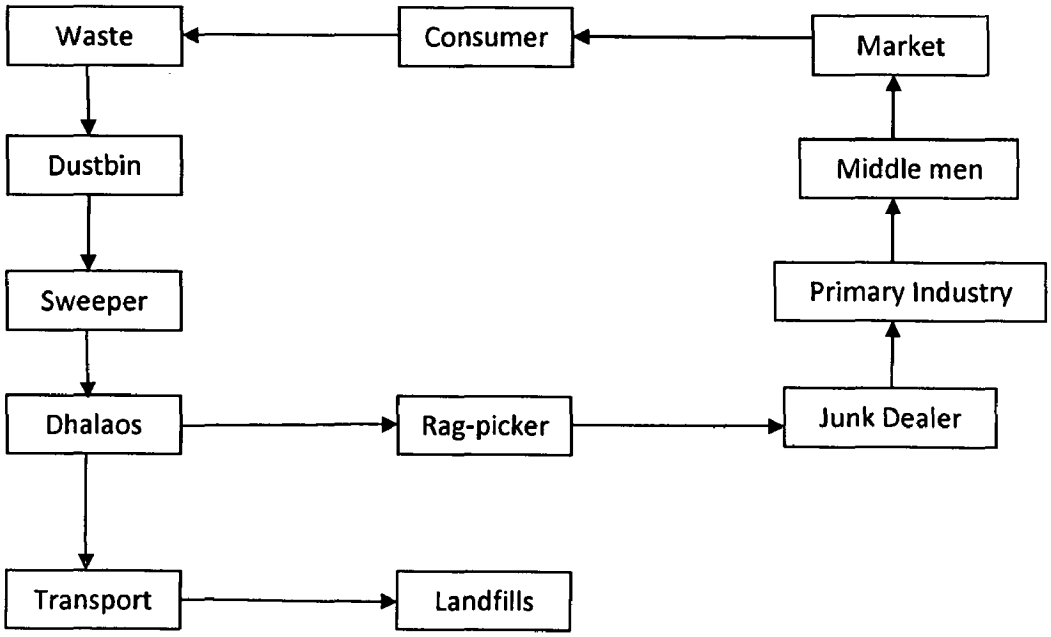
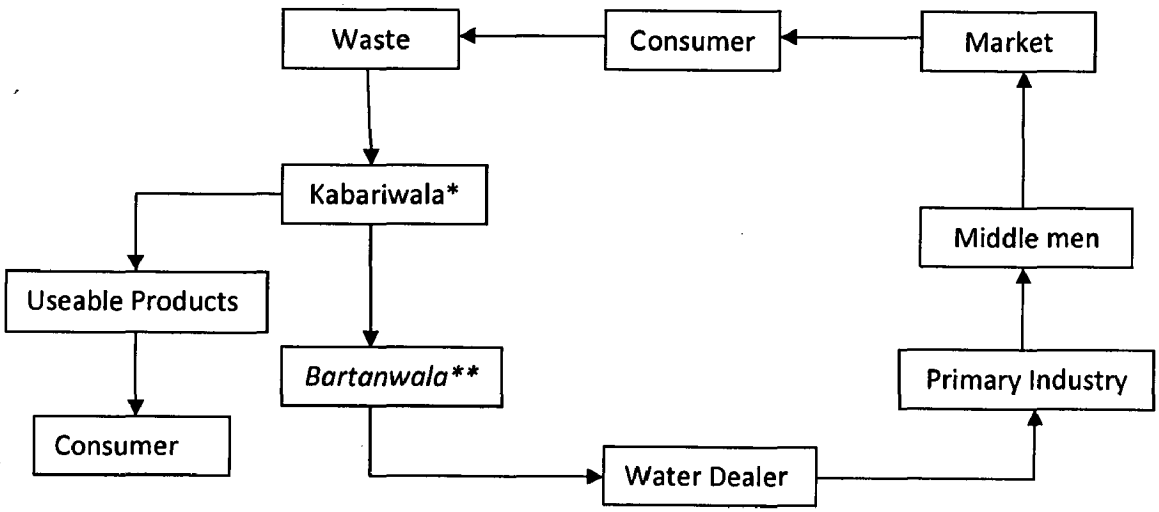


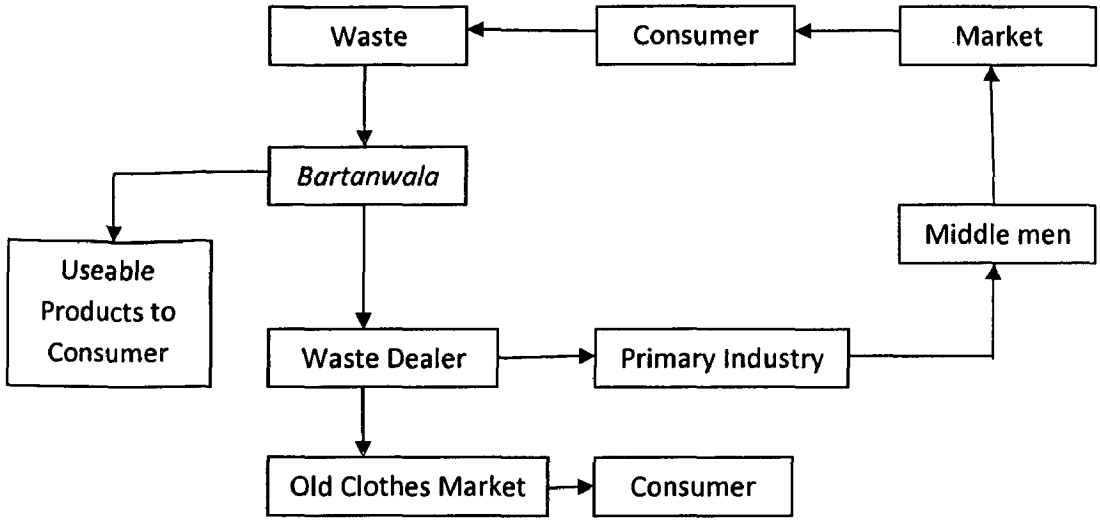
Fig. 4 Plastic products



Note: - Around 60% of plastic waste generated is recycled and used in manufacturing of various plastic products.

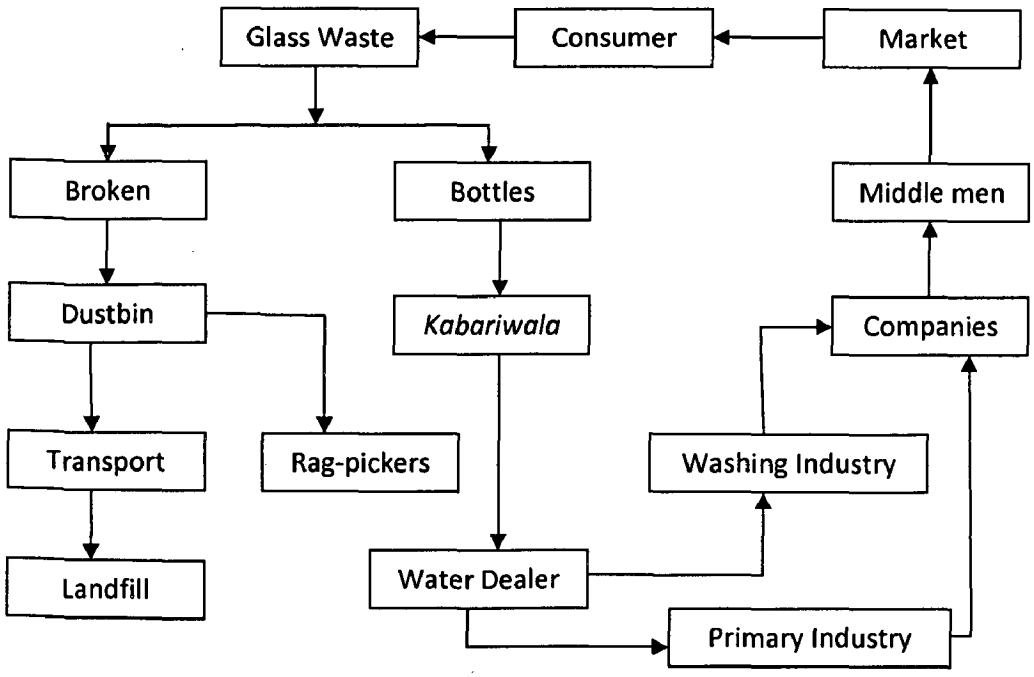
*Person trading with old and refuse items segregated at household level.
**Person trading with old / new metal utencils.

Fig. 5 Old Clothes



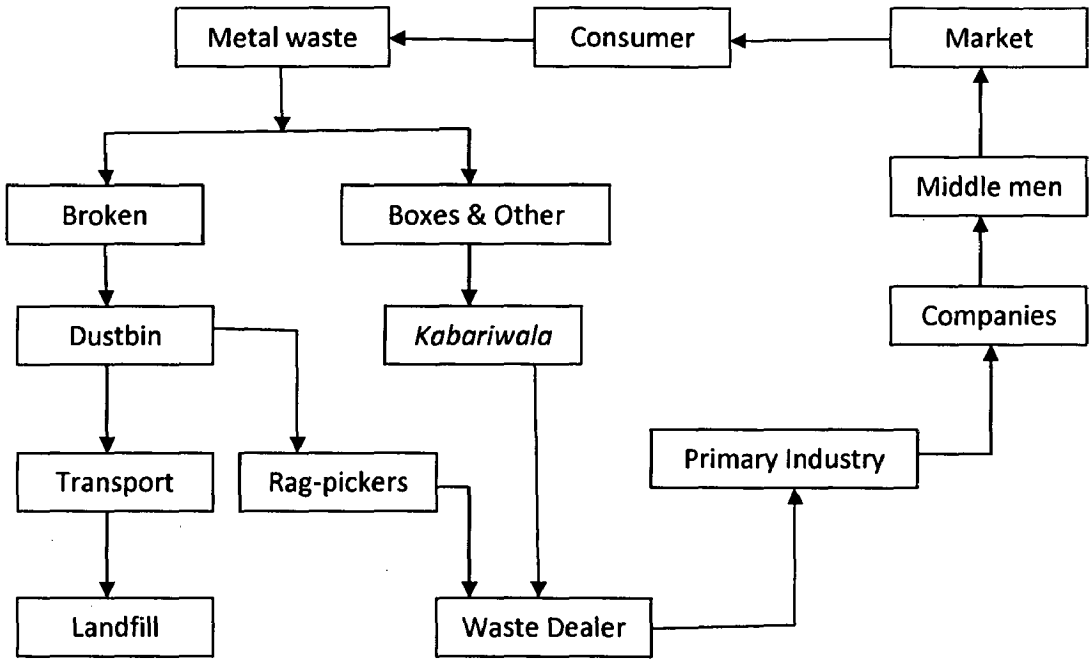
Note: - Old clothes are generally used for making carpets and poor quality fiber.

Fig.-6 Glass waste



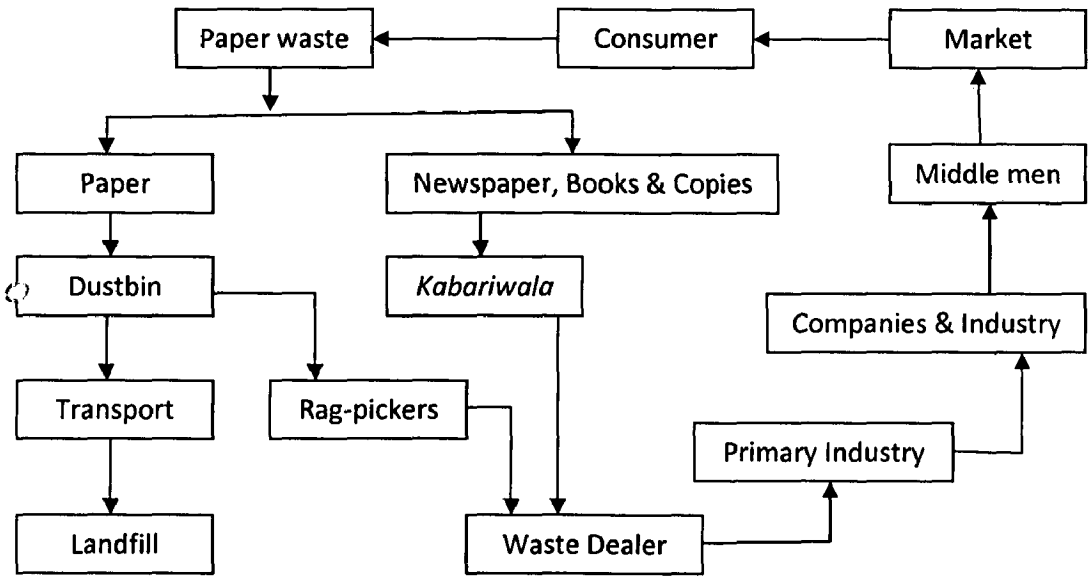
Note: - Broken glass is moulded again to make glass products. Bottles are washed and sent back to respective companies.

Fig. 7 Metallic waste



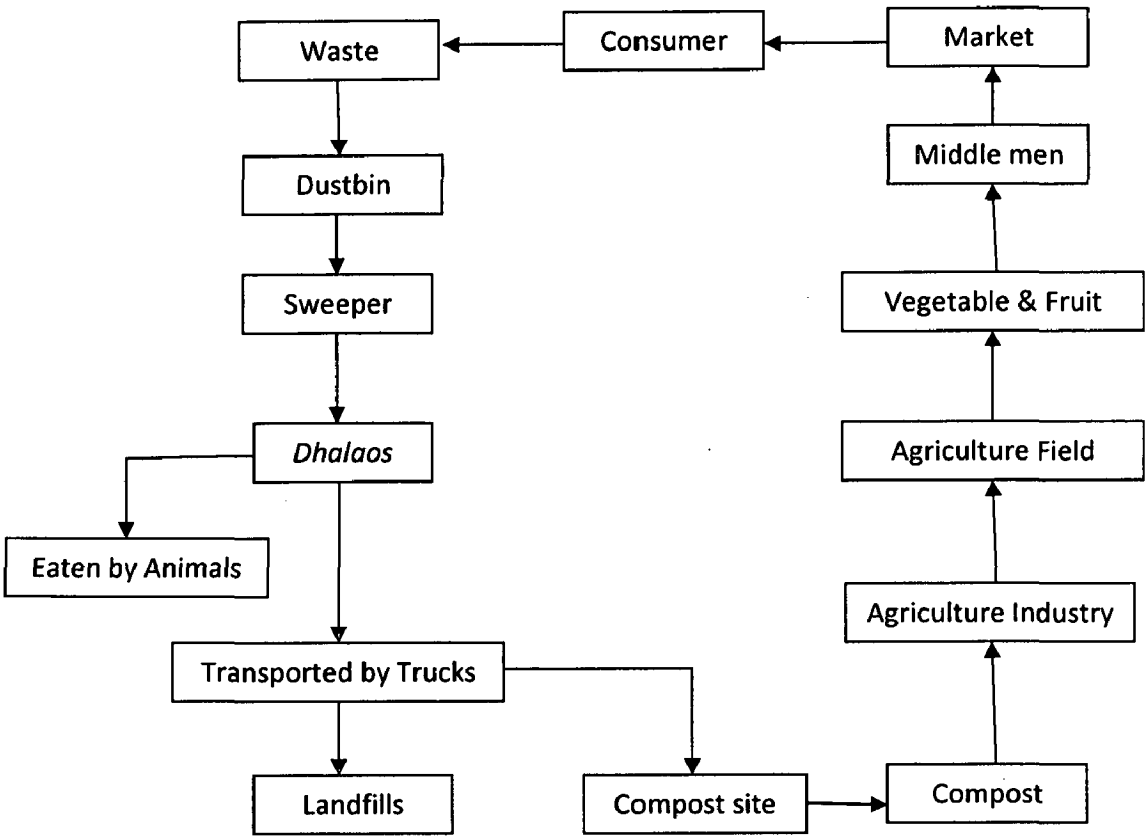
Note:- Metal waste is moulded and used for making metallic products.

FIG. 8 Paper waste



Note: - Paper waste is used for making poor quality paper and various types of boards.

Fig. 9 Vegetables and other organic waste



Note:-Organic waste constitutes nearly 45 percent of the total waste and it was found that only 7-10 percent of overall waste is used for making compost and the remaining waste is decomposed at landfills. This organic waste attracts birds and other animals at the sites which create nuisance.

In the recent past, private sectors have taken initiatives to use this waste as a profitable venture.

Some of the technological options available are listed below:

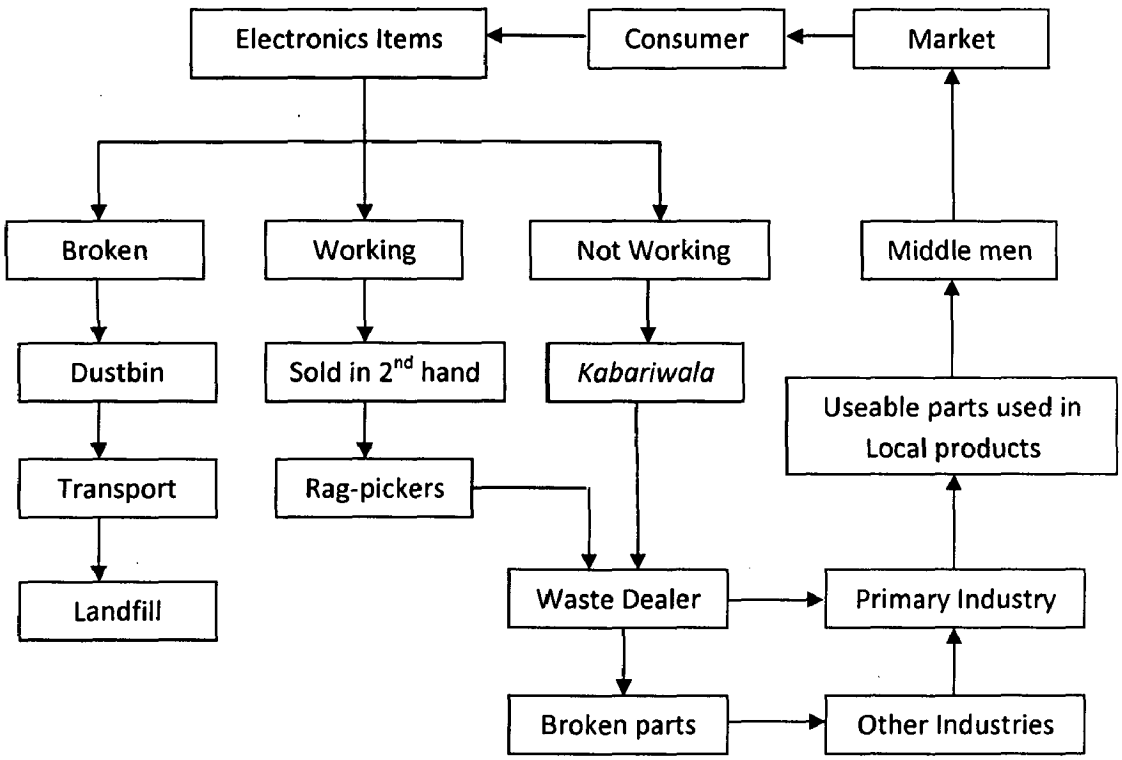
1. Biomethanation
2. Sanitary Landfill gas
3. Pelletisation
4. Pyrolysis

5. Incineration

6. Composting

However, because of the higher cost of production, these techniques are under trial.

Fig. 10 Electronics item waste.



Note: - Generally, the electronics items which are in working condition are sold to second hands. The items which are not working are sold to kabariwala, which in turn are sold to waste dealer. The waste dealer segregates the parts and useful items are sold to local manufacturer. Other parts go in waste in industries based on their material and recycled to use in some other manner.

3.3.12 The Waste Management System

Waste from the generators such as households, institutions etc. is brought to the street corner bins (SCBs) according to their convenience. The responsibility of conveying the waste from the point of generation to the WSDs or the SCBs lies in the hands of the generators. Usually the street sweepers or the rag-pickers are employed by the people for this purpose. The waste is segregated at the WSDs by the *dhalao* workers and the rest is taken away by the vehicles. An appreciable amount of wet waste is taken to the centralized compost plant at Bhalaswa .The rest is taken to the Bhalaswa landfill. The waste segregated at the WSDs is taken to the central workshop at Subhash Nagar where the waste is further segregated into different streams and is taken in bulk for recycling. A centralized segregation facility has also been proposed and will be developed as soon as the land is provided by the MCD for the same.

3.3.13 The Collection and Transportation System

The collection system has undergone a drastic change since the inception of the private sector in solid waste management. Prior to the privatization, waste from the waste storage depots was collected in open trucks. The problems such as waste spillage and odour were common.

Moreover, the staff carrying out the collection of the waste without the provision of any safety equipment such as the mask, gloves, boots etc. was highly vulnerable to potential health hazards. Also the whole system was inefficient and poorly managed. The waste in the WSD used to rot for several days. There was no proper scheduling or tracking of the waste collection vehicles. Also the waste was collected without any discrimination between the wet and the dry portion and was picked in the mixed form. Minimization of the waste going to the landfill was totally neglected.

The system has undergone a huge transformation since the privatization. Compactor loaders are being used for the transportation of the waste. Containerized mechanical loading and unloading is done which avoids multiple handling, reduces spillage, ensures hygienic environment around the WSDs and

also reduces environmental and health risks. Moreover, separate vehicles are used for biodegradable (green) and non-biodegradable waste (blue). A major chunk of the biodegradable portion is sent to a centralized composting facility. The whole transportation activity is managed by a fleet of 34 vehicles including 16 compactors, 9 mini refuse collectors (RCs) and 9 high capacity dumper trucks operated by a total of 51 drivers and 72 helpers. The capacity of the vehicles varies between $3m^3$ and $16m^3$. They are directly managed by a strong team of supervisors (including team leaders) which are 49 in number. The movement of the vehicles takes place according to the proper schedule and is tracked by a *state-of-the-art* command and control system. Command and control communication devices comprise of 34 wireless sets on vehicles, 32 wireless handsets with operational and technical staff and 50 cellular phones. Moreover, the on road movement of the vehicles is tracked by a special Global Positioning System (GPS) enabled system. 100 percent waste collection and disposal is ensured within 24 hours and is achieved in 3 shifts of 6 hours each. Break-up vehicles are also maintained to keep the stability of the system intact, in the case of vehicular breakdown and also for handling complaints.

3.3.14 Waste Segregation

Waste segregation has been considered while handing over the responsibility of waste management to the private sector. Table 3.1 shows the segregation benchmark set for the corresponding months and the applicability of the penalty if the benchmark is not achieved:-

Table 3.1: Assigned Segregation Benchmarks and the Penalty

Year of operation	Month from COD	SB=Segregation Benchmark for corresponding * Month(in % terms)	R=applicable Penalty for Corresponding Month (in % terms)
Year 1	1-12	0	Nil
Year 2	13-24	5	15%
Year 3	25-36	10	15%
Year 4	37-48	12	15%
Year 5	49-60	15	15%
Year 6	61-72	18	15%
Year 7	73-84	20	15%
Year 8	85 onwards	20	15%

*The percentage of the total number of vehicle trips to the landfill site during the preceding month which has duly passed the tests relating to level of biodegradability in accordance with the O&M requirements.

STUDY AREA PROFILE

4.1 Study Area: Muzaffarpur City

The city of Muzaffarpur is the headquarter of Muzaffarpur district and is the largest city of North Bihar. It is situated on the south bank of perennial river *Burhi Gandak.*

4.2 Muzaffarpur District: Introduction

Muzaffarpur District is one of 37 districts of Bihar state, India, The district is a part of Tirhut Division and is one of the largest commercial and educational centres of North Bihar.

It is famous for litchis which is a fruit famous for its juicy taste. The district has won international encomiums for its delicious *shahi leechi* and *china leechi.*

Figure: 4.1 A Leechi Orchard Showing Ripened Fruit

The district occupies an area of 3,123 km². As per 2001census, the district had a population of 37,43,836 out of which 19,41,480 was male population and 18,02,356 female population. Male to female population ratio for the district was 1000: 928.It has an average literacy rate of 48.15 % (male literacy 60.19 %, and female literacy 35.20 %).

The district was created in 1975 for the sake of administrative convenience by splitting up the earlier district of Tirhut and was named after Muzaffar Khan, an *amil* (revenue officer) under British dynasty.

The Muzaffarpur district is surrounded by *East Champaran* and *Sitamarhi* districts on the North, *Vaishali* and *Saran* districts on the South, *Darbhanga* and *Samastipur* districts on the East and *Saran* and *Gopalganj* districts on the West.

Boundaries of Muzaffarpur District, Map (4.1)

4.3 A Brief History of Muzaffarpur

The recorded history of the district dates back to the rise of the *Vrijjan Republic.* This Republic was a confederation of eight clans of which the *Licchavis* were the most powerful and influential. Even the powerful *Magadh Kingdom* had to conclude matrimonial alliances with the *Licchavis* in 519 B.C. Ajatshatru invaded Vaishali and extended his sway over Tirhut. It was at this time that *Patliputra* (the modern Patna) was founded at the village *Patali* on the bank of river Ganga. Ajatshatru built an invincible fortress to keep vigil over the Licchavis on the other side of the river.

Amravati, the village believed to be the home of *Amrapali,* the famous royal court dancer of Vaishali, is situated only 40 kms from Muzaffarpur.

Vaishali, a center of religious renaissance, the birth place of Lord Mahavir, the *24th Jain Tirthankar* and a contemporary of Lord Buddha, continues to attract visitors from across the international borders.

Muzaffarpur was under the control of Maharaja Harsha Vardhan, a powerful sovereign of North India from the time of Hieuen Tsang's visit till the rise of the *Pala Dynasty.* After 647 A D, the district passed on to the local chiefs.

In the 8th century A D, the Pala Kings continued to have their hold over Tirhut until 1019 A D. The Chedi Kings of Central India also exercised their influence over Tirhut till they were replaced, towards the close of the 11th century. by the Rulers of the *Sena Dynasty.*

Nanyupa Deva, the founder of *Simraon Dynasty,*in the north-east part of Champaran, extended his power over the whole of Mithila and Nepal. During the regime of the last king of the dynasty, Tughlaq Shah invaded Tirhut in 1323 and gained control over the territory. Tughlaq Shah handed over the management of Tirhut to Kameshwar Thakur. Thus, the sovereign power of Tirhut passed from the Hindu chiefs to the Muslims but the Hindu chief continued to enjoy complete autonomy uninterruptedly.

By the end of the 14th century, the whole of North Bihar including Tirhut passed on to the kings of Jaunpur and remained under their control for nearly a century until they were defeated by Sikandar Lodi of Delhi.

Meanwhile, Hussain Shah, the Nawab of Bengal, exercised his control over large tracts including Tirhut. The Emperor of Delhi defeated Hussain Shah in 1499 and got control over Tirhut. With the decline and fall of Shahs, North Bihar including Tirhut formed a part of the mighty Mughal Empire.

The victory of East India Company in 1764 at the battle of Buxar gave them control over whole of Bihar and they succeeded in subduing the entire district.

The success of the insurgent at Delhi in 1857 caused grave concern to the English inhabitants in this district and revolutionary fervor began to permeate the entire district. Muzaffarpur played its role and was the site of the famous bomb case of 1908 by a young Bengali revolutionary, Khudi Ram Bose.After independence, a memorial to this young revolutionary patriot was constructed at Muzaffrapur, which still stands.

The political awakening in the country after the 1st World War stimulated nationalist movement in Muzaffarpur district also. The visit of Mahatma Gandhi to Muzaffarpur district in December 1920 and again in January 1927 had tremendous political effect in arousing the latent feelings of the people and the district continued to play a prominent role in the country's struggle for freedom.

Muzaffarpur played a very significant role in the history of north-eastern India. The peculiarity of Muzaffarpur in Indian civilization arises out of its position on the frontier line between two most vibrant spiritual influences and most significantly, to this day, it is a meeting place of Hindu and Islamic culture and thoughts.

4.4 District Muzaffarpur At a Glance

(a) Administrative Units of Muzaffarpur District

No. Of police district	1
No. Of sub-divisions	2
No. Of blocks	16
No of circles	15
No. Of police stations	28
No. Of out posts	11
No. Of halkas	141
No. Of panchayats	387
No. Of villages	1811

Source: http://en.wikipedia.org/wiki/Muzaffarpur.

(b) Commercial Activity and Banking Facilities of Muzaffarpur District

Muzaffarpur is one of the main commercial centers of North Bihar. To serve its various banking needs, **there** are more than 190 branches of various banks. (Commercial Bank -101 branches, Gramin Bank-76 branches, Co-operative Bank-9 branches, Land development Bank-5 branches)

The lead bank of Muzaffarpur district is the Central Bank of India.

(c) Educational Institutes of Muzaffarpur District

District Muzaffarpur is also one of the important educational centers of North Bihar as is evident by the following table of various educational institutes:-

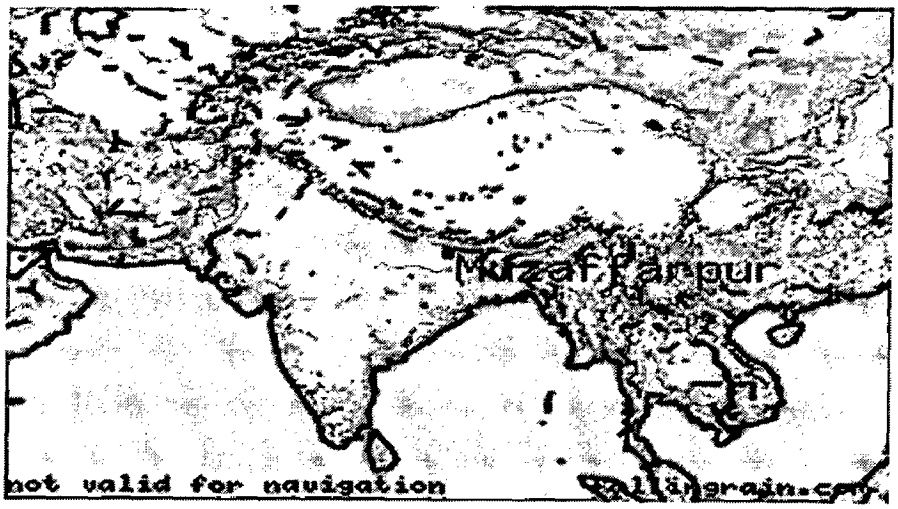
INSTITUTION CATEGORY	NUMBER
University	1
Engineering college	1
Medical colleges	2
Iti	1
Polytechnics	2
Primary & basic schools	2225
Middle schools	397
High schools	101
Project schools	6
[10+2] high schools	6
Degree colleges	15
Post graduate colleges	4
Law college	1
Management institutions	2
Primary teachers training colleges	4
Teacher training college	1
Physical training college	1

Source: http://en.wikipedia.org/wiki/Muzaffarpur.

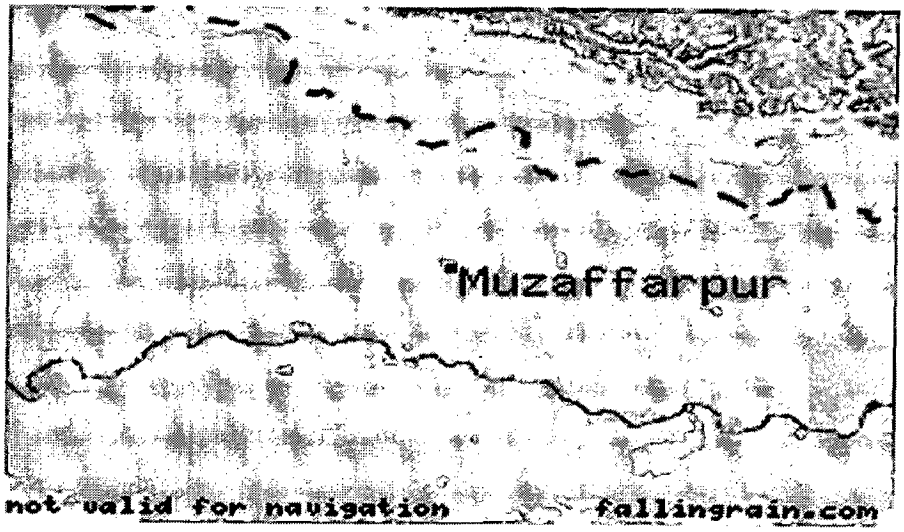
(d) Important Rivers of Muzaffarpur District

There are four main rivers with their tributaries in the district. These are *Gandak, Burhi Gandak* and *Lakhandei(*a tributary of Bagmati*).*

4.5 Location of Muzaffarpur in Satellite Maps



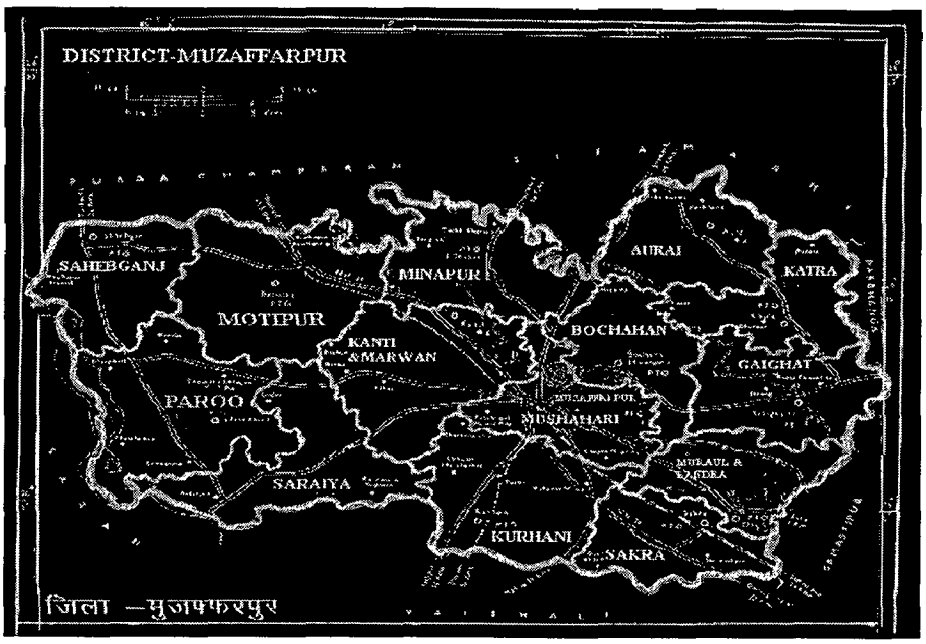
Satellite Map (4.2)



Satellite Map (4.3)

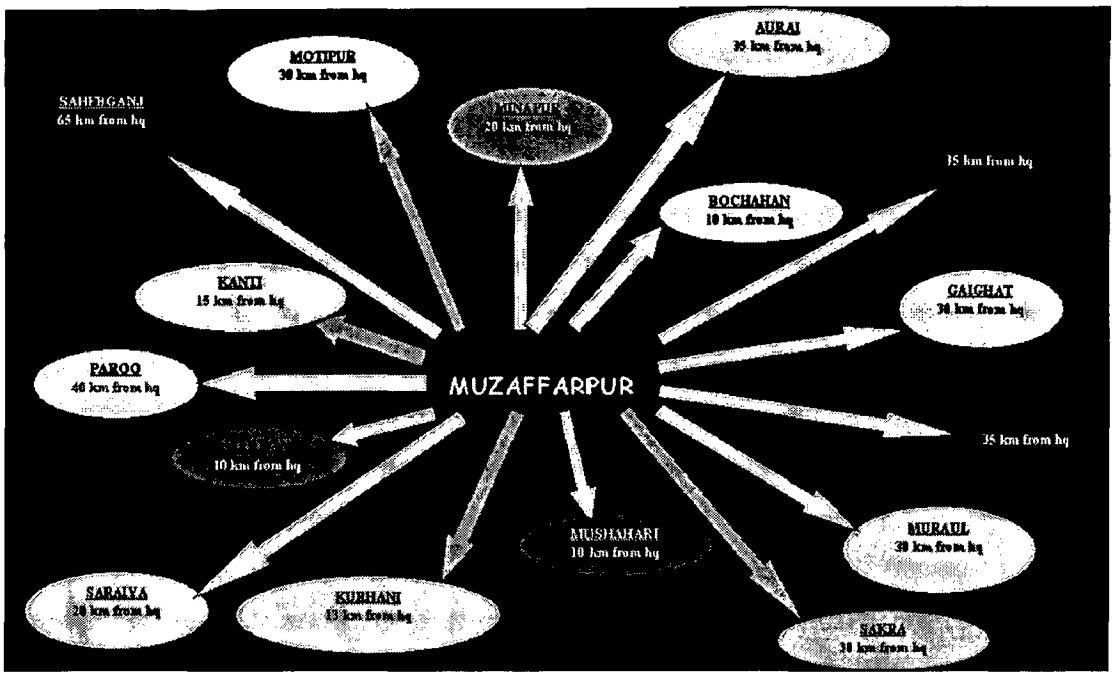
Satellite Map (4.4)

4.6 Map Showing Various Administrative Blocks of Muzaffarpur District



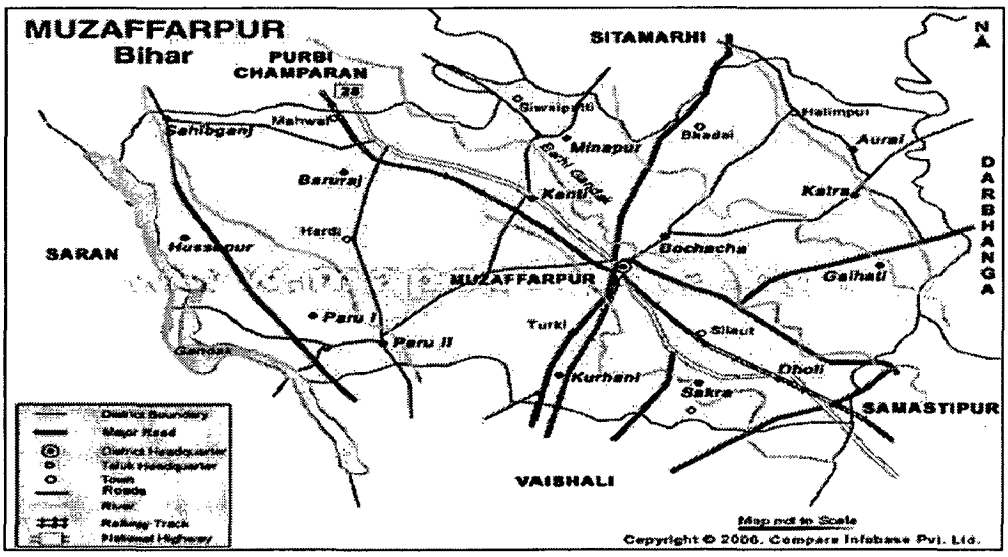
Muzaffarpur District, Map (4.5)

4.7 Train and Road Connectivity of Various Administrative Blocks of Muzaffarpur District



Connectivity map (4.6)

4.8 Road Map of Muzaffarpur District



Road map (4.7)

Source: http://en.wikipedia.org/wiki/Muzaffarpur.

4.9 Muzaffarpur City at a Glance

(a) Geography

Muzaffarpur is located at LATITUDE 25^{O} 54'N TO 26^{O} 23'N

LONGITUDE 84^{O} 53'E TO 85^{O} 45'E

It has an average elevation of 47 meters. The town lies in a highly active seismic zone of India.

Other geographical information is as under:-

(a) Geographical area-317591 ha,

(b) Cultivated area- 247721 ha,

(c) Non – cultivated area-59270 ha.

(d) Irrigation area-82964 ha,

(e) Horticulture area-16667 ha.

(b) Demographics

As per 2001 census, Muzaffarpur city had a population of 3,05,465. Males constitute 54% of the population and females 46% and 13% of the population is under 6 years of age.

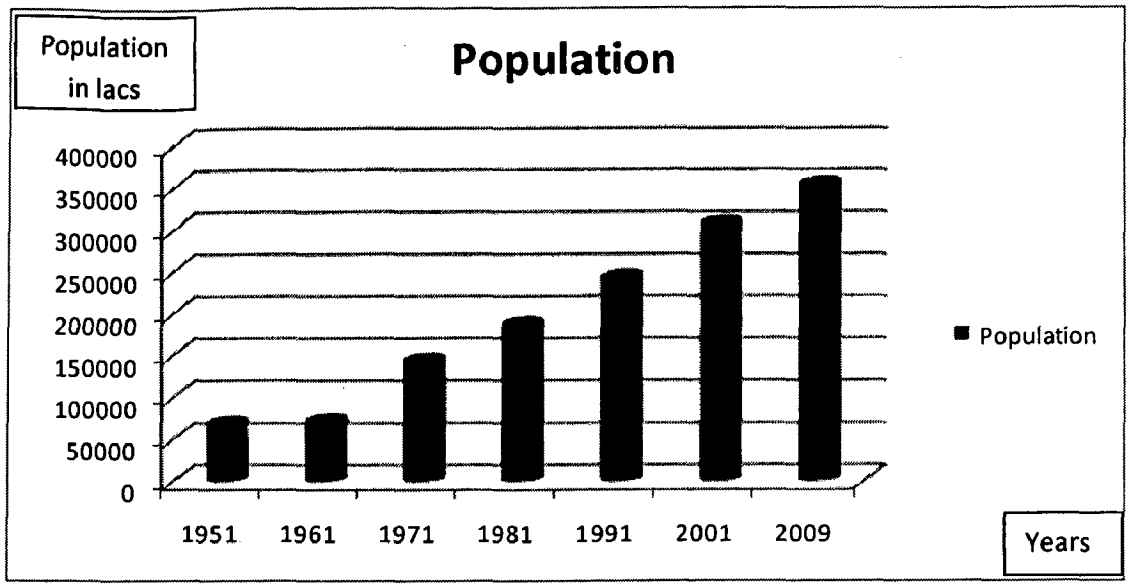
Muzaffarpur has an average literacy rate of 60%, higher than the national average of 59.5%. Male literacy is 62 %, and Female literacy is 57%.

(c) Population Growth

The populations of the city during the past decades have been shown in the population growth graph.

The current population of the city (2009) is 3, 51,284.75 while in 2021, the population is estimated to become 4,03,977+ (Including floating population).

It seems that the population of the city registered maximum growth during 1961-71 and second highest growth rate was seen during 1971-81 as well as 1981-91 which indicate the economic development of the city. After that the rate of population growth dropped to 24.81%.



Graph showing Population Growth in Muzaffarpur City

Graph-4.1

Source: http://en.wikipedia.org/wiki/Muzaffarpur

(d) Ward-wise Population Distribution of Muzaffarpur Municipal Corporation (MMC)

Table:-4.1

WARD No.	POPULATION	POPULATION DENSITY (Persons/ha)
1.	5,662	63.74
2.	7,109	90.94
3.	5,619	180.40
4.	6,033	251.42
5.	6,256	245.17
6.	6,614	178.32
7.	5,885	86.31
8.	6,710	228.17
9.	5,854	60.84
10.	6,566	107.38
11.	5,822	66.74
12.	6,481	89.91
13.	5,287	90.88
14.	6,110	152.85
15.	5,967	85.01
16.	6,599	285.11
17.	6,664	195.53
18.	6,106	276.82
19.	6,956	365.26
20.	6,947	298.83
21.	6,557	308.44
22.	5,537	386.98
23.	6,289	280.27
24.	6,306	264.58
25.	6,306	179.71
26.	6,306	229.04
27.	6,306	201.97
28.	5,868	86.06
29.	6,175	156.83
30.	6,281	209.09
31.	5,568	141.59
32.	5,820	133.48
33.	6,182	93.32
34.	6,366	169.05
35.	6,681	63.50
36.	6,429	86.06
37.	5,623	132.30
38.	6,850	253.11
39.	6,688	476.57
40.	6,676	102.73
41.	6,186	199.03
42.	7,035	200.5
43.	5,576	327.06
44.	6,362	396.63
45.	5,367	40.24
46.	6,596	40.50
47.	6,114	45.51
48.	5,819	62.40
49.	6,349	21.69
TOTAL	**3,05,465**	**8,687.87**

Source: Muzaffarpur Municipal Corporation

(e) Map showing different Municipal Wards of Muzaffarpur City

(f) Map showing Ward-wise Population and Population Density of Muzaffarpur City (for detailed viewing)

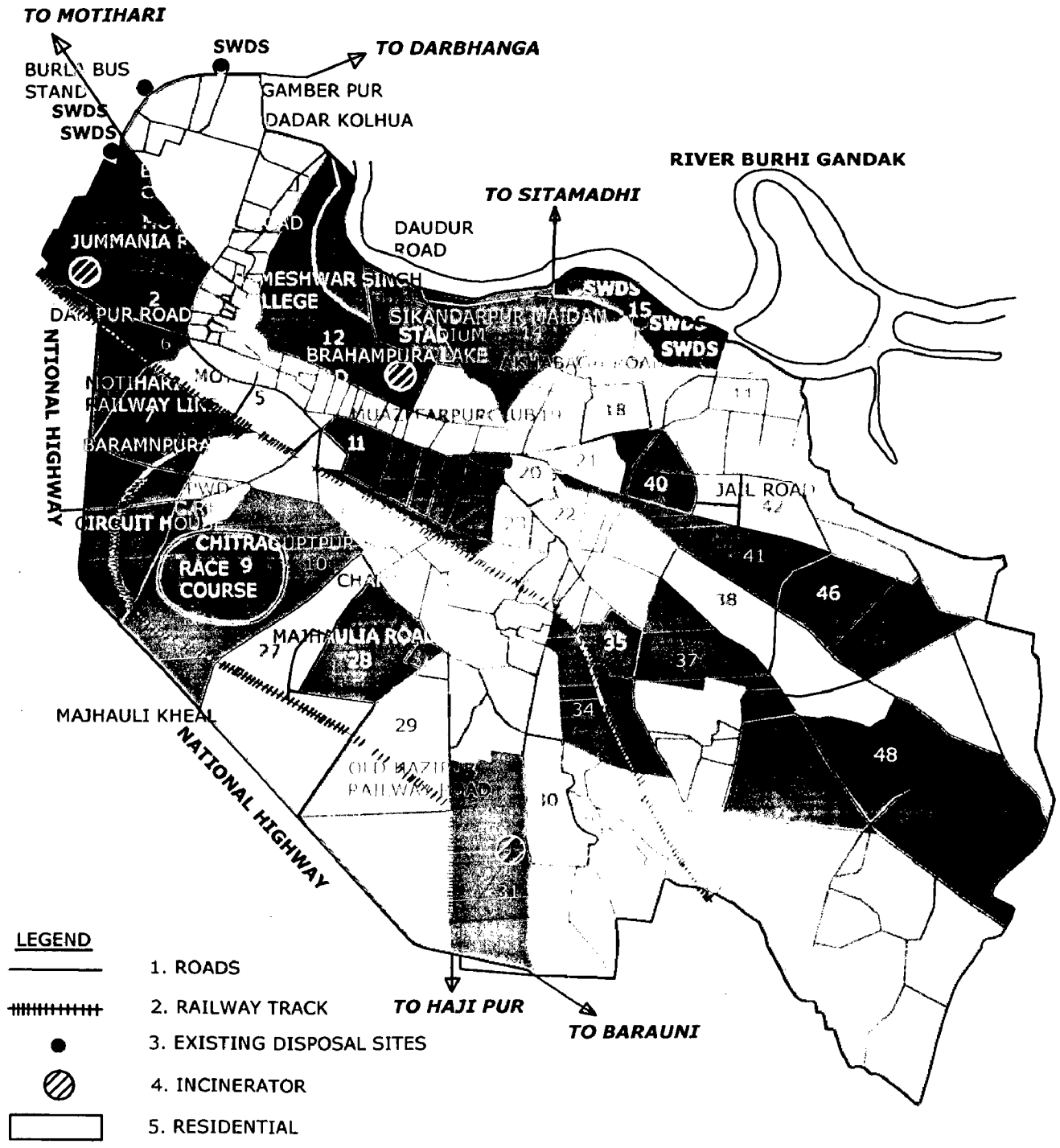
(g) Map showing Population Density of Municipal Area on the basis of 5 different density slabs (for overall viewing)

(h) Map showing Solid Waste Disposal Sites (SWDS) of Muzaffarpur City

(i) Map showing Collection route of MSW in Muzaffarpur City

(j) Map showing Estimated Future Boundary of Muzaffarpur City

49 MUNICIPAL WARDS OF MUZAFFARPUR CITY,BIHAR

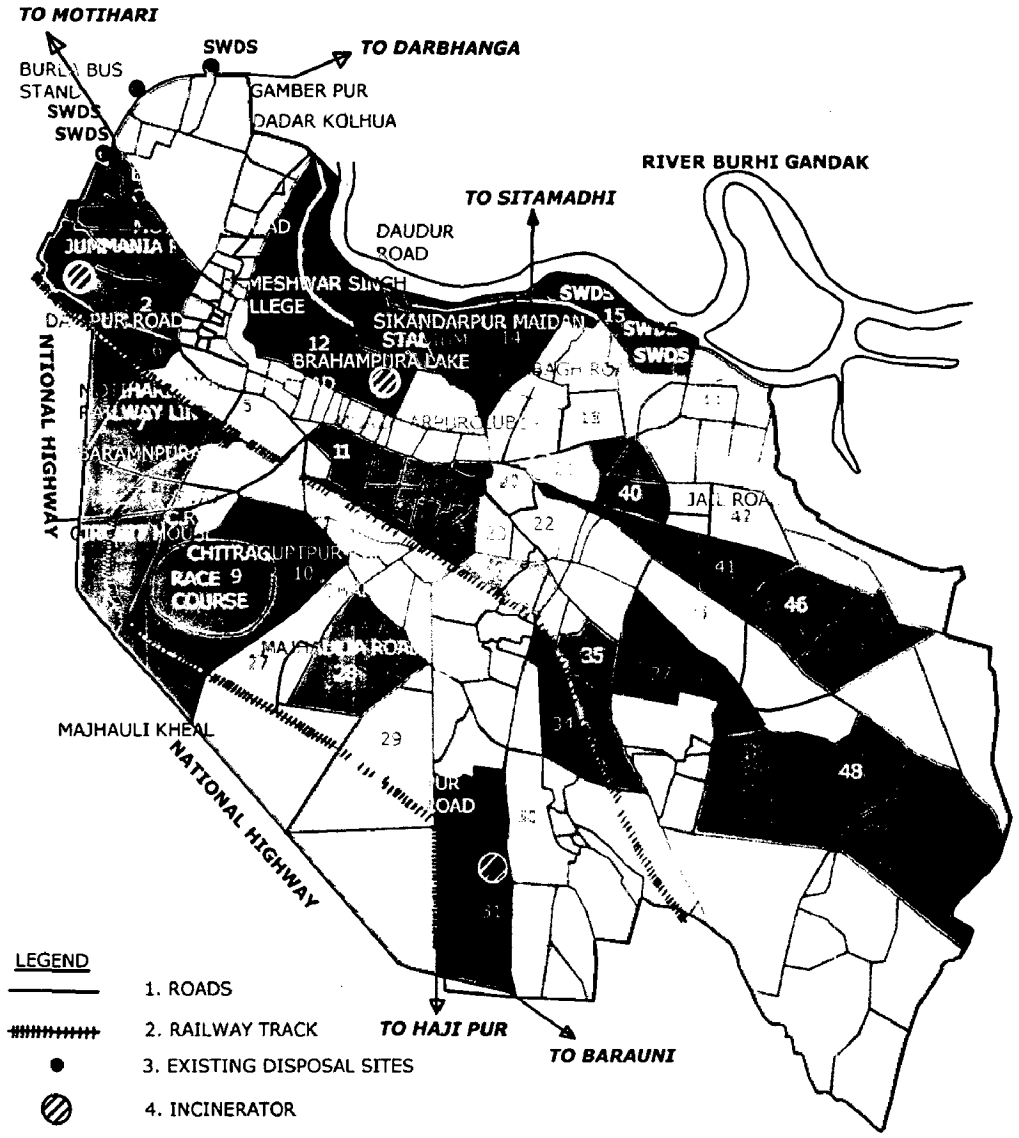


LEGEND

1. ROADS
2. RAILWAY TRACK
3. EXISTING DISPOSAL SITES
4. INCINERATOR
5. RESIDENTIAL

NOTE:- SWDS = SOLID WASTE DISPOSAL SITE
SCALE = 1: 80000

MAP-1



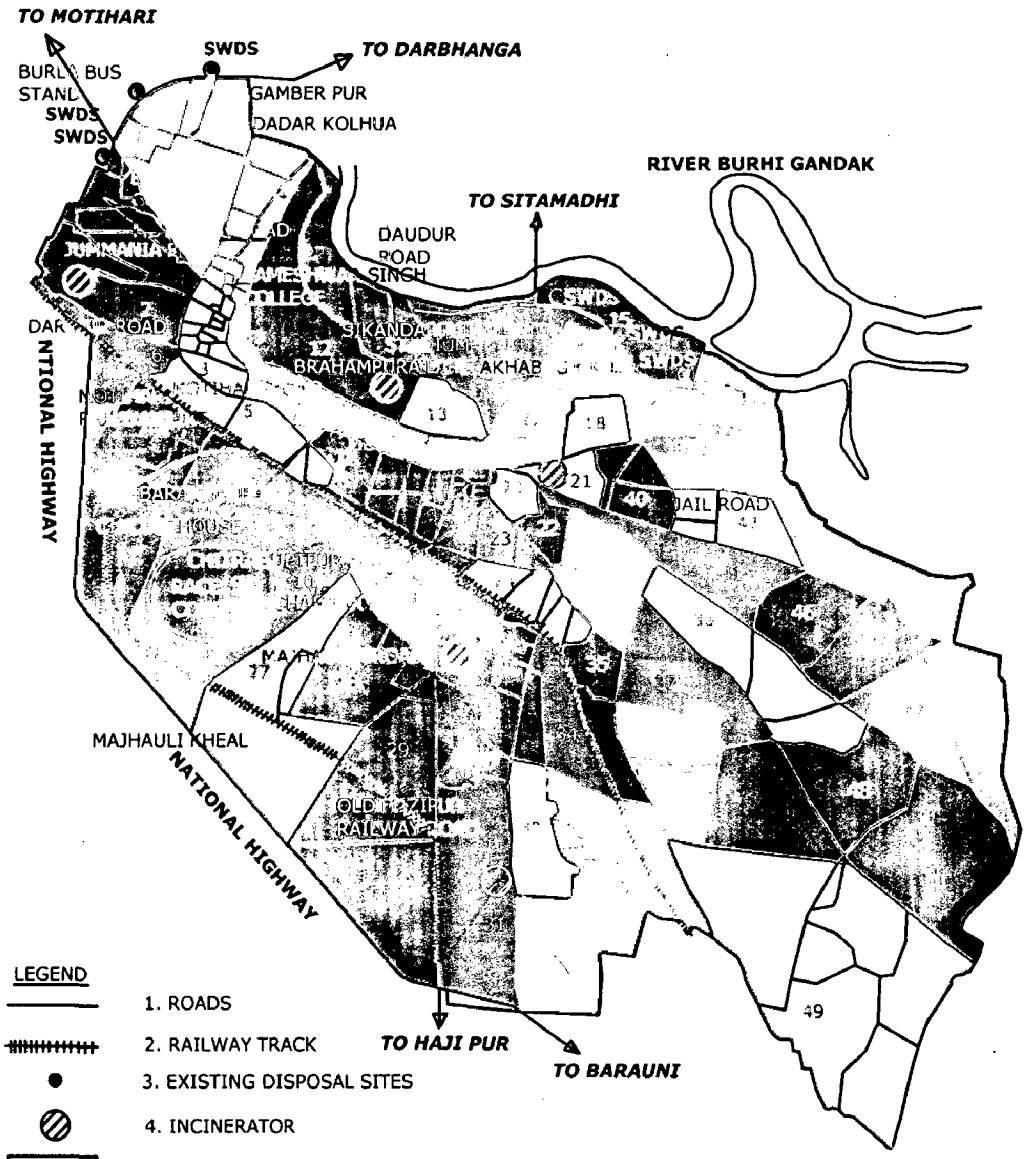
NOTE:- SWDS = SOLID WASTE DISPOSAL SITE
SCALE = 1: 80000

MAP-2

/HACTARE

	0-100	1,2,7,9,11,12,13,15,28,33, 35,36,45,46,47,48,49
	101-200	3,6,10,14,17,25,29,31,32, 34,37, 40,41
	201-300	4,5,8,16,18,20,23,24,26,27, 30,38,42
	301-400	19,21,22,43,44
	401-500	39

WARD NOs.	P.D (P/ha)	WARD NOs.	P.D (P/ha)
1.	63.74	26.	229.04
2.	90.94	27.	201.97
3.	180.40	28.	86.06
4.	251.42	29.	156.83
5.	245.17	30.	209.09
6.	178.32	31.	141.59
7.	86.31	32.	133.48
8.	228.17	33.	93.32
9.	60.84	34.	169.05
10.	107.38	35.	63.50
11.	66.74	36.	86.06
12.	89.91	37.	132.30
13.	90.88	38.	253.11
14.	152.85	39.	476.57
15.	85.01	40.	102.73
16.	285.11	41.	199.03
17.	195.53	42.	200.5
18.	276.82	43.	327.06
19.	365.26	44.	396.63
20.	298.83	45.	40.24
21.	308.44	46.	40.50
22.	386.98	47.	45.51
23.	280.27	48.	62.40
24.	264.58	49.	21.69
25.	179.17	TOTAL	8,687.87

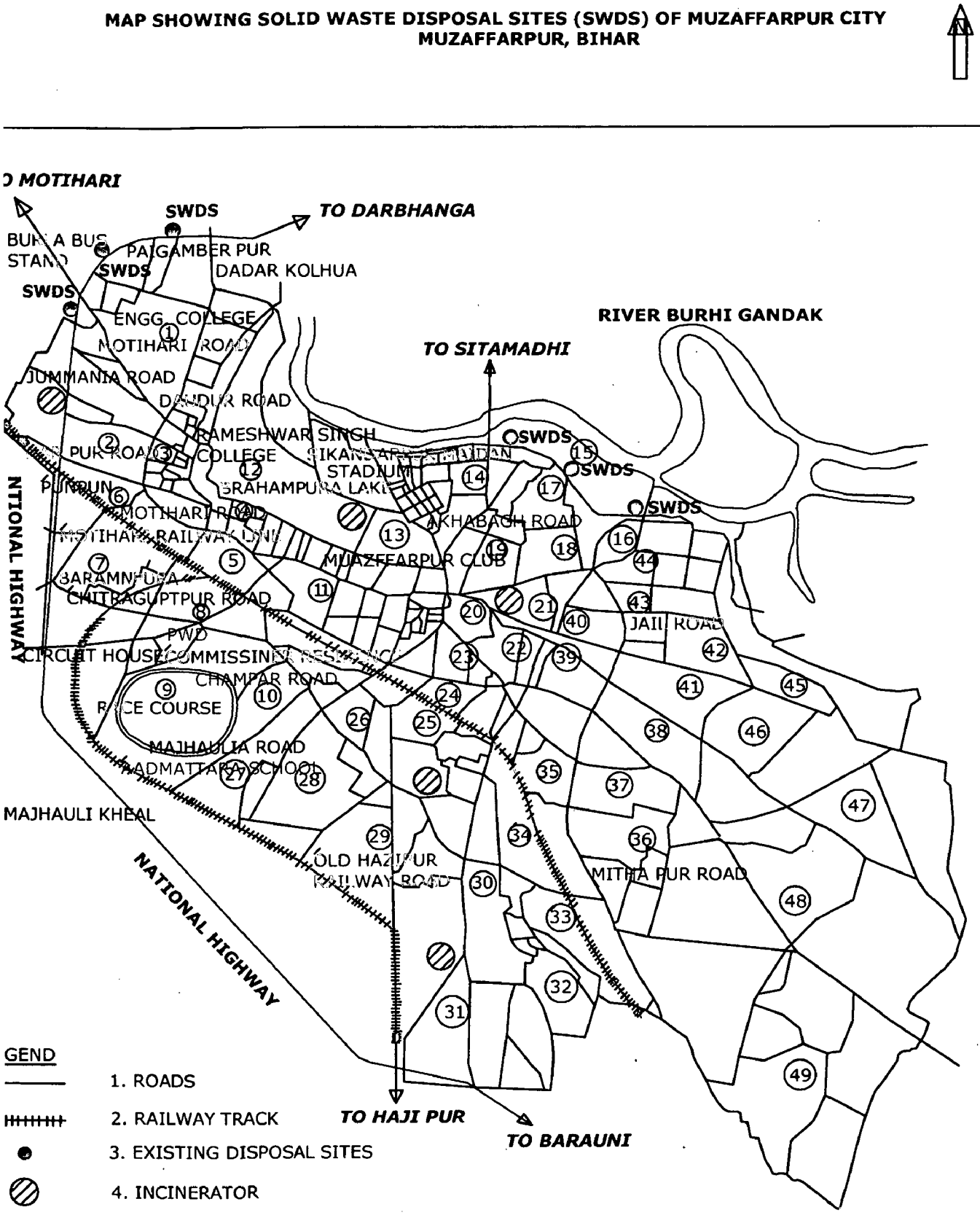


NOTE:- SWDS = SOLID WASTE DISPOSAL SITE
SCALE = 1: 80000

MAP-3

	0-100	1,2,7,9,11,12,13,15,28,33, 35,36,45,46,47,48,49
	101-200	3,6,10,14,17,25,29,31,32, 34,37, 40,41
	201-300	4,5,8,16,18,20,23,24,26,27, 30,38,42
	301-400	19,21,22,43,44
	401-500	39

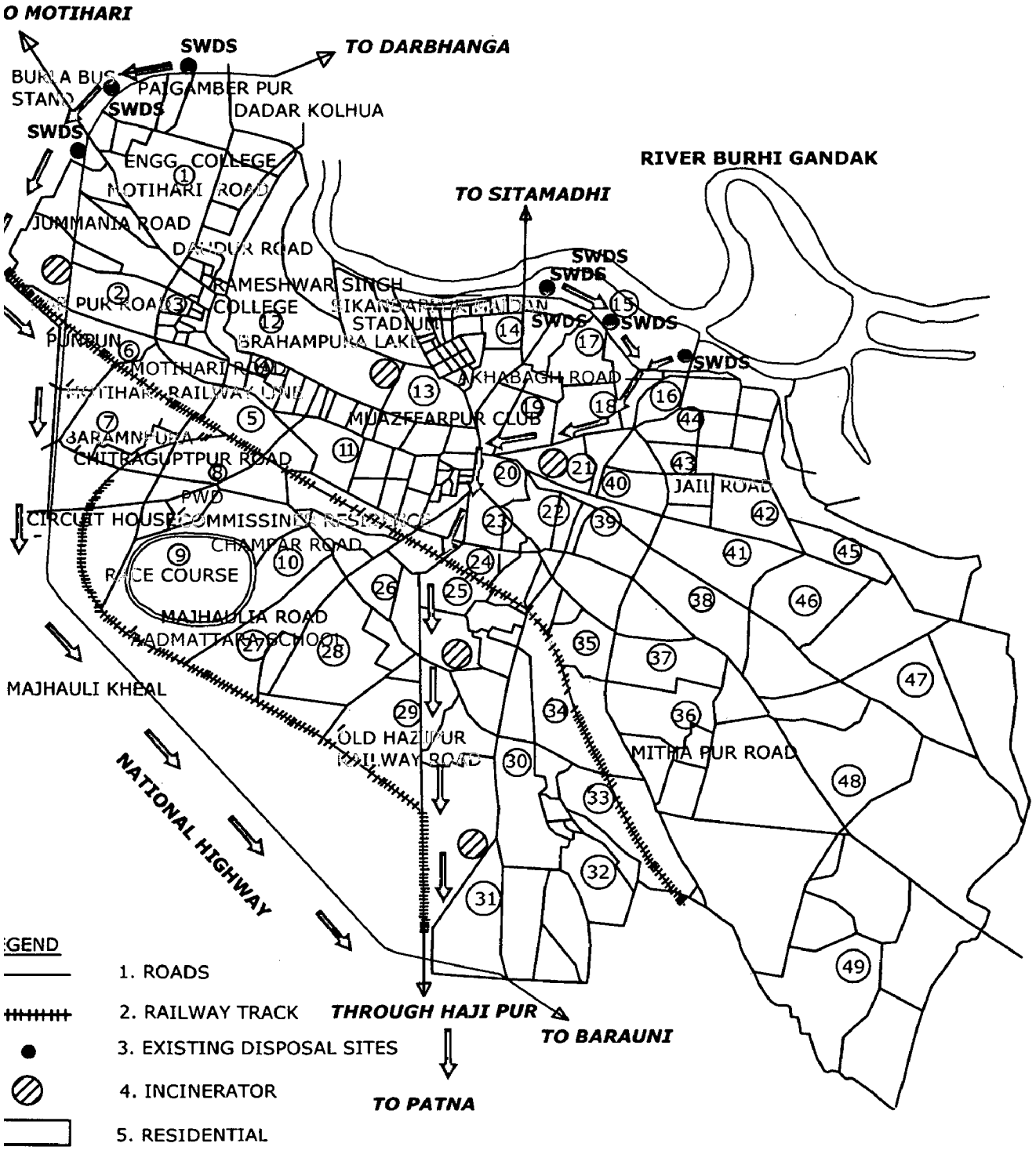
MAP SHOWING SOLID WASTE DISPOSAL SITES (SWDS) OF MUZAFFARPUR CITY
MUZAFFARPUR, BIHAR



NOTE:- SWDS = SOLID WASTE DISPOSAL SITE
SCALE = 1: 80000

MAP-4

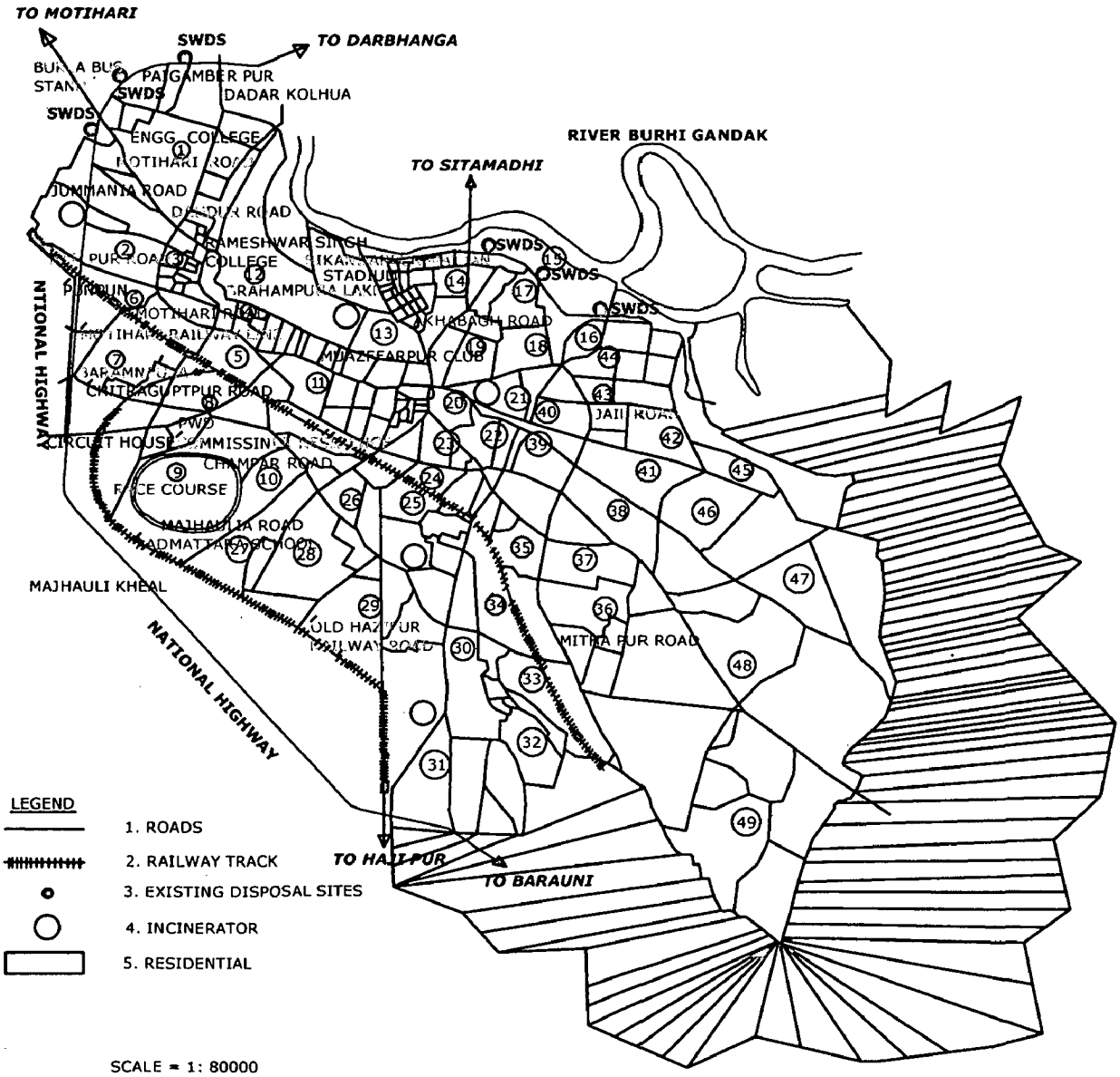
COLLECTION ROUTE OF MUNICIPAL SOLID WASTE
MUZAFFARPUR CITY, BIHAR



NOTE:- SWDS = SOLID WASTE DISPOSAL SITE
SCALE = 1: 80000

MAP-5

ESTIMATED FUTURE BOUNDRY OF MUZAFFARPUR CITY.(YEAR 2021)



NOTE:- 1. THE AREA SHOWN IN BLUE STRIPES IS THE EXPECTED EXTENSION, WHICH EXTENDS VIRTUALLY IN EAST,EAST-SOUTH AND SOUTH DIRECTIONS.
2. IT IS LEAST LIKELY TO EXTEND IN NORTH, NORTH-WEST AND WEST DIRECTIONS DUE TO THE PRESENCE OF RIVER BHUDHI GANGA AND NATIONAL HIGHWAY .

MAP-6

DETAILD STUDY FOR SWM OF MUZAFFARPUR CITY

5.1 Pictures Showing Office of the MRDA

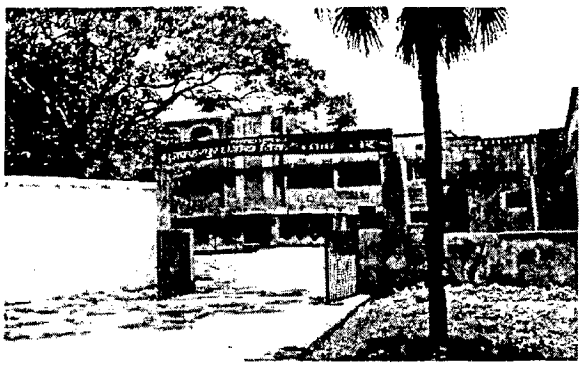


Figure: 5.1 Office of the MRDA, Main Gate

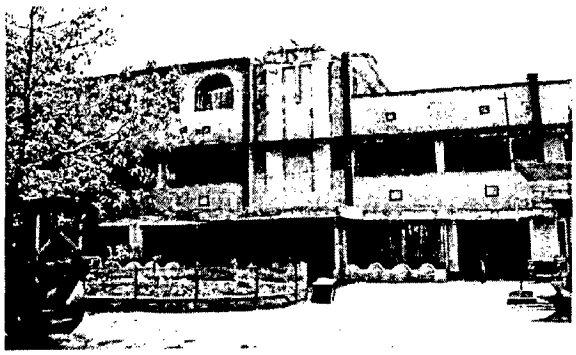


Figure: 5.2 Office of the MRDA, Main Building

5.2 Pictures Showing Office of the MMC

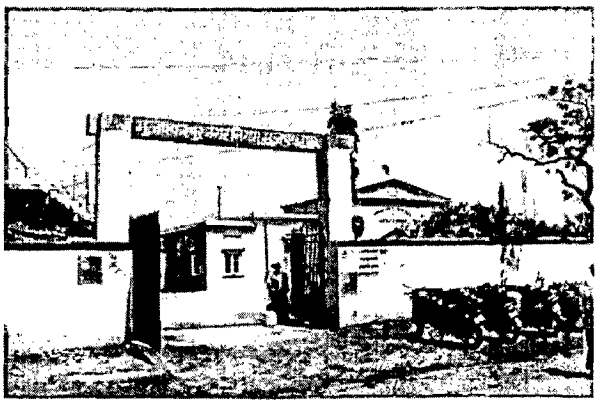


Figure: 5.3 Office of the MMC, Main Gate

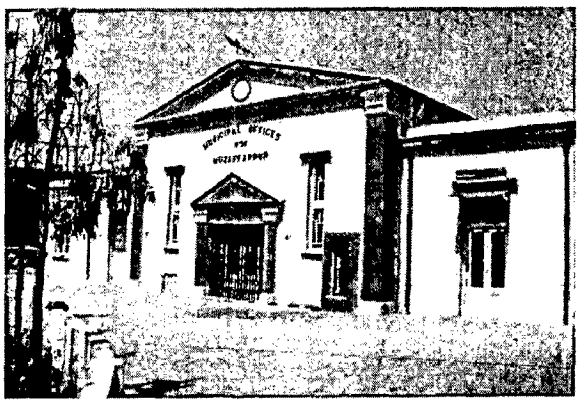


Figure: 5.4 Office of the MMC, Main Building

Source: - Photographs taken by the Author, 2008

5.3 Pictures Showing Various Aspects of SWM

Figure: 5.5

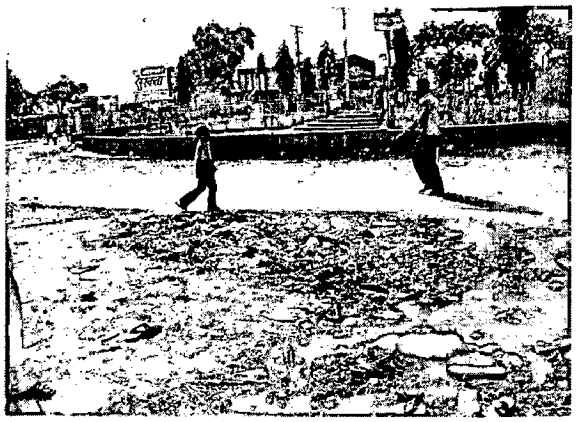


Figure: 5.6

Figure: 5.7

Figure: 5.8

Unplanned and Hap-hazard Collection of MSW at various sites

Source: - Photographs taken by the Author, 2008

Figure: 5.9 A Cow is seen browsing Waste Materials on a busy road

Figure: 5.10 Solid wastes Heaped on a foot-path around an electric pole

Figure 5.11: A Rag-picker searching for Recyclable Solid waste from MSW lying Scattered On a busy Street

Figure 5.12: A Rag-piker Collecting Recyclable Solid Waste

Source: - Photographs taken by the Author, 2008

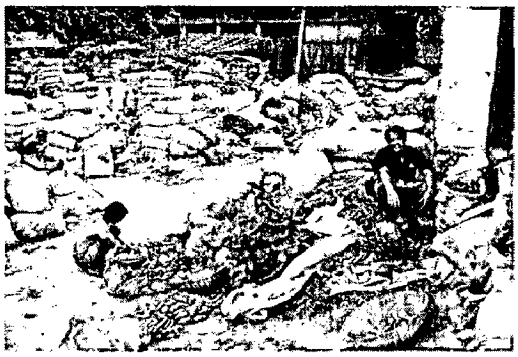


Figure: 5.13

Figure: 5.14

Pictures showing segregation of recyclable solid waste in proces

Figure: 5.15

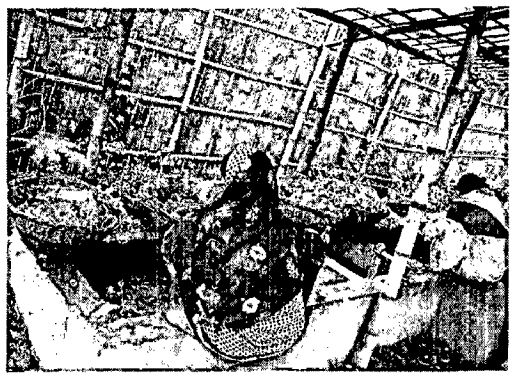


Figure: 5.16

Pictures showing Glass bottles, segregated from MSW, being washed for recycling purpose

Source: - Photographs taken by the Author, 2008

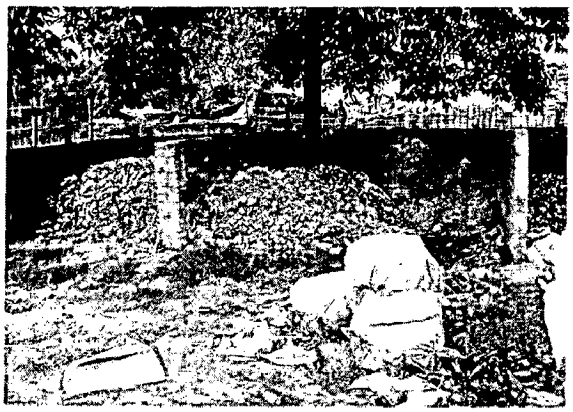


Figure: 5.17

Figure: 5.18

Pictures showing storage and packaging of recyclable materials from the Municipal Solid Waste

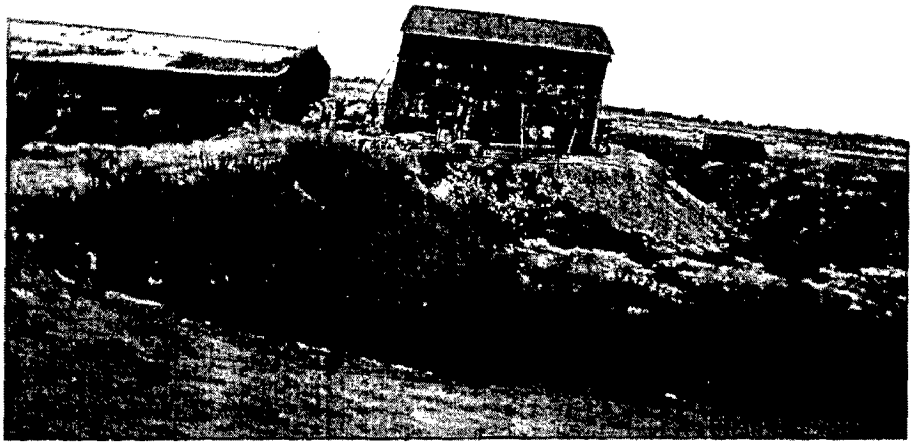


Figure: 5.19 A Transit Storage Facility of recyclable Solid Waste on the Bypass Road (Muzaffarput to Darbhanga)

Source: - Photographs taken by the Author, 2008

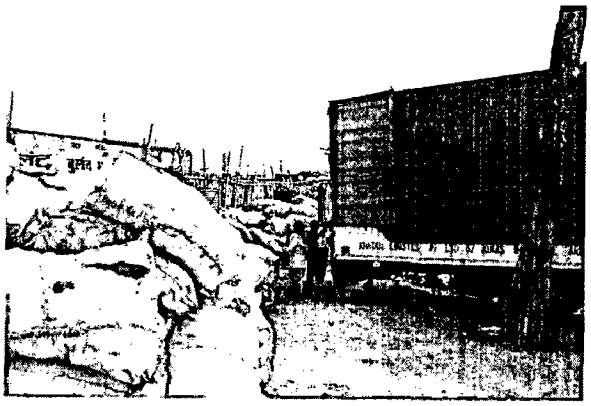


Figure 5.20

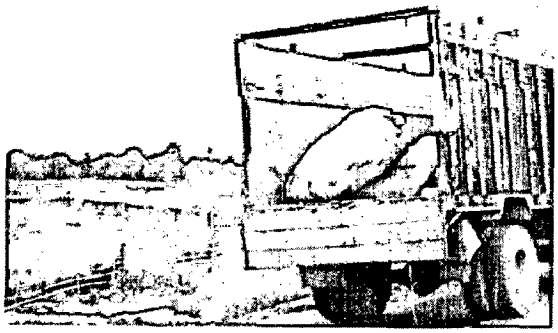


Figure 5.21

Pictures Showing Segregated Materials Being Transported for Recycling

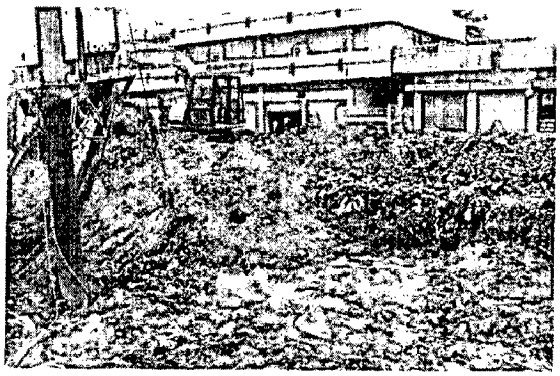


Figure: 5.22 MSW Being Used at a Landfill Site

Figure: 5.23 Contamination of Water by MSW

Source: - Photographs taken by the Author, 2008

ANALYSIS AND FINDINGS

6.1 Introduction

Amongst the developing countries of the world India is a densely populated country. Its density is far more than other developed and developing countries (except that of China). After the industrial revolution the pace of urbanization has experienced rapid growth. Due to industrialization cities began to grow, new urban centers were formed, and existing cities grew larger. This rapid urbanization gave rise to such problems which were never experienced before.

Due to large population load and population density, urbanization took place in a hap-hazard manner in India. The rate of urbanization in India is about 50% decadal growths. Provisions of urban infrastructure, however, could not keep pace with the increasing size and population of the cities.

In today's world when market system and economic activities are the governing factors, the economic condition of a city acts as an index of development. Better the economic condition, more is the development. More the development; better are the infrastructural facilities in a city.

We can draw a conclusion that without the development of infrastructure, economic development is not possible. Better infrastructural facilities ensure smooth functioning of a city.

6.2 Description of MMC Staff Set-Up and Problems

Having a present population of 3,51,285 (excluding floating population of approx 1.75 lacks), the Muzaffarpur Municipal area produces about 478 tones of solid waste daily.MMC is lacking in staff, machineries a automobiles and is unable to carry out its work of collection, transportation and disposal of municipal solid waste efficiently.

MMC has 2430 sanitary workers (including regular and temporary),and 68 number of different types of automobiles as shown in table 6.1 and 6.2:

Table 6.1 Existing Sanitary Workers in Muzaffarpur Municipal Corporation

Workers	Nos.
Street sweeping	1700
Transportation and disposal of waste	250
Temporary labors	480
Total	2430

Table 6.2 Existing Automobiles in Muzaffarpur Municipal Corporation

Vehicle type	Nos.	Vehicle type	Nos.
Tractors	15	Trolleys	14
Mini Trucks	10	Auto Rickshaw	7
Tipper (with 4 dumpers)	01	JCB	02
Refuge Compactor	07	Mini Refuge Compactor	02
Sewer Cleaning Vehicle	02	Loader	01
Dumpers	06	Crane	01
		Total	68

Source: - Integrated Urban Development in Bihar , Muzaffarpur City.

6. 3 Solid Waste Description

Waste generation: 0.49 kg/person/day;

Waste composition: approx. 47% Organic and rest non-biodegradable / recyclable; Collection rate: 60-70%;

Recycling of metal, glass, plastic: formal, carried out by scavengers;

Composting: carried out by a private company which composts 20% of municipal solid waste and compost is sold commercially.

Open dumping: remaining solid waste is dumped openly on various landfill sites on the out-skirts of the city. Expenditure: 20% of the municipal budget.

Incineration: no such facility has been established yet due to inhibitive costs of plant set-up and its running and maintenance.

6. 4 Calculation

The year 2021 envisages a comprehensive and sustained solid waste management system with modern and scientific answers to collection, transportation and disposal of about 546 MT/Day of solid waste and biomedical waste.

Table 6.3 Forecasting of Solid Waste for Future

S.N	DESCRIPTION	2001	2009	2021
1	Total Waste generated (MT/Day)	413	478	546
2	% waste collected to generated	50-60	60-70	70-80
3	% of waste composted	10	20	35
4	% of waste recycled	20-30	25-40	45-60
5	Total Vehicle Capacity / total waste generated	0.5	0.6	1.0
6	Trips / vehicle	2	2	2-3

Source: Analysis by the author

6.5 Current Requirement of Sanitary Workers:

Waste produced per head is 0.49 kg/person/day.

The present resident population of Muzaffarpur City = 3, 51,285 (in 2009)

The floating population of Muzaffarpur city =175.6 lacs (approx.)

Total domestic waste (54 %) produced = 525 x 0.49 = 257 metric tonnes.

Total municipal solid waste produced = 478 metric tonnes/day

Capacity of a Tractor to carry the SW = 2.0 metric tonnes.

Capacity of a Mini truck = 3.0 metric tonnes.

Capacity of a Dumper each with 5 bins = 2.0 metric tonnes

Assume, if there are five people in one family, then one sanitary worker will be required for 73 families (or on an average 3 sanitary workers will be required per 1000 population).

One tractor makes 2 trips a day and one mini truck also makes 2 trips a day.

4 personnel are required with each mini-truck/ tractor

The total no. of Sanitary Workers required is 4000

but the MMC has 1570 number of workers, so the additional number of workers required are:-

4000 - 2430 = 1570 nos.

A total 1570 number of workers are required for better solid waste collection, transportation and disposal in present day.

6.6 Projected Requirements

The overall density will increase from 10,870 persons per sq km to 12,501 persons per sq km.

The area is likely to increase from 32.316 sq km to 37.126 sq km

According to the standards of one ward per 15,000 population, the number of municipal wards may not be required to be increased as the current average density of each ward is about 6234 persons which is much below the standard.

The production of the SW is likely to increase from the existing 700 tonnes to 801 tonnes. The existing infrastructure facilities have to be increased accordingly.

The land required for the disposal of the SW will also have to be increased accordingly.

6.7 Issues and Measures in Collection

A large number of city inhabitants habitually dispose off waste indiscriminately in streets, open yards, and drains. As a result, more number of sanitary workers needs to be employed and consequently a percentage of the municipal budget is to be spent for street sweeping as a central part of collection activities. Additionally, municipal solid waste collection rates are low due to an insufficient number of sanitary workers and collection vehicles, as well as difficulties in entering narrow lanes/ streets.

However, the MMC is striving to encourage the participation of residents and businesses and to make effective use of existing human resources and equipment, thereby developing a new method for waste collection through public-private cooperation.

6.8 Issues and Measures in Promotion of Recycling

Scavengers i.e., rag-pickers make a major contribution to the reduction of waste. However, scavengers who rummage through the waste bins and scatter the garbage are exposed to environmental and hygienic problems. As pointed out by MMC, this problem needs to be addressed as a large number of scavengers are poor and include women and children.

Advantages of addressing this problem adequately would include lessening the above said detrimental impact on the health of scavengers as well as the surrounding environment, creation of new jobs, finding solutions for financial problems faced by MMC as the first step towards the development of recycling business.

The most effective method to increase recycling rates is to promote separation of recyclable domestic solid waste at the household level. Objective of decreasing recyclable waste must address issues such as understanding and cooperation of residents, enlarging market for recycled materials, and the construction and development of fully-equipped recycling facilities.

In targeting the intermediate layer that possesses an awareness of the environmental problems, various measures have been successful, such as the distribution of cash or coupons to residents that have separated recyclable materials at household level and thus have contributed effectively in collection of such segregated waste for the purpose of recycling.

6.9 Issues and Measures In Composting

The bio-degradable component of the municipal solid waste needs to be composted adequately. Addressing this issue will serve a dual purpose, firstly – lessening the quantum of the solid waste to the disposed of and, secondly – composting it profitably to lessen financial burden on the MMC.

This case demonstrates the use of waste from markets as material for composting, as well as active participation and cooperation among the municipal authority and the businessmen.

This issue should address problems arising from difficulties in selling the compost. Agriculturists and cultivators need to be convinced that compost contains high nitrogen levels and is suitable as fertilizer for cultivating vegetables. Compost is less expensive than chemical fertilizers and has more favorable impact on the soil in terms of organic cultivation.

6.10 Issues and Measures in Financing

The rate for waste treatment fees in the general budget is high, and because there is lack of finances, there are a number of cases where fees are levied in order to cover treatment costs. One method to increase cost effectiveness is the creation of partnerships with residents and the private sector.

6.11 Financial Challenges

Improvements in planning, financial and managerial capacity are major strategies for the MMC. Additionally, the MMC aims to increase operating revenue through user charges, service taxes, landfill taxes and tipping fees. These measures would relieve financial limitations that are currently issues for the municipality.

Well-trained human resources remain a bottleneck for effective planning and management, which are being improved by ongoing capacity building activities. Partnerships with the private sector, community groups and NGOs are also sought as major strategies. The MMC has paid special attention to legal impediments and labour concerns for private sector participation.

6.12 Wastes from Health Care Establishments

The Health Care Establishments such as hospitals, nursing homes and clinics generate infectious waste in addition to other wastes. Though infectious waste forms only 10-15% of the total hospital waste, it is often collected along with the other waste

aggravating the problem. Only a few establishments incinerate their waste, while majority of them dispose off their waste in the municipal waste stream.

Actions needed to be undertaken

- Biomedical wastes are governed by Biomedical Wastes (Management & Handling) Rules, 1998 which need be enforced strictly.

- The biomedical wastes should not be allowed to mix with the municipal solid waste.

6.13 Health Hazards due to Improper Solid Waste Management

Improper waste management is associated with increased health problems in all sections of the population. Breeding of flies and mosquitoes occurs whenever the waste remains uncollected from the community bins and due to improper operation of disposal sites. When human excreta and hospital wastes are mixed with municipal solid waste, the workers are exposed to infectious agents. Solid waste workers often have to work without protective gloves and gumboots as a result they get infected from these sources.

When the municipal solid waste is mixed with hazardous industrial waste, the solid waste workers are exposed to various infections and chemical hazards. Similar health problems are also faced by the rag pickers.

The waste characteristics are expected to change due to increasing urbanization, commercialization and improved standard of living. The present trend indicates that the paper and plastic content has increased while the organic content in the waste has decreased. Although the organic content is on the decrease, it is still suitable for biodegradation as the calorific value continues to be unsuitable for incineration.

Due to rapid urbanization, prevailing land use regulations and competing demands for procurement of land, it is desirable that adequate land for solid waste disposal be earmarked at the planning stage itself. Larger quantities of solid waste

produced and higher degree of urbanization will necessitate better management involving a higher level of expenditure on manpower and equipments.

Actions needed to be undertaken

- Protective devices such as gumboots, hand gloves and masks should be provided to the solid waste workers.
- Adequate medical facilities should be provided to the workers at concessional rates.
- Medical allowance should be paid to the workers to encourage them.
- Separate primary health center should be established for the workers.

6.14 Role of Infrastructure:

Infrastructure may be defined as the frame work of facilities, utilities and support system through which goods and services are provided to the public. These facilities are of two types, Social and Physical.

6.15 Physical Infrastructure It Comprises:

Road network

Electricity

Water supply

Sewerage & drainage

Solid waste disposal system

6.16 Staff Set-up of Muzaffarpur Municipal Corporation (MMC):-

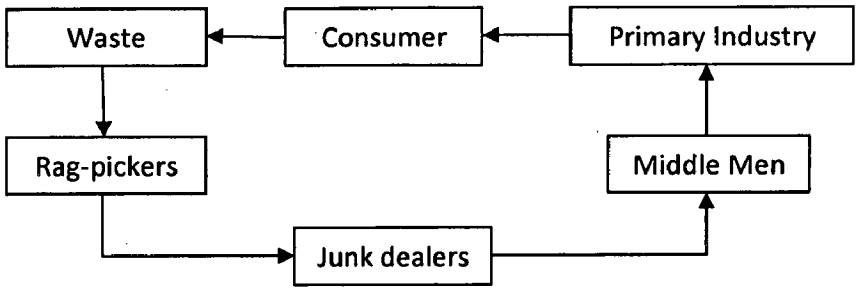
At present, MMC lacks in adequate number of municipal staff and automobiles. The available automobiles are not maintained properly .The work shop situated in Muzaffarpur

city is not working efficiently. In absence of proper maintenance, the available automobiles are not utilized properly. Most of them remain unused lying in the garages.

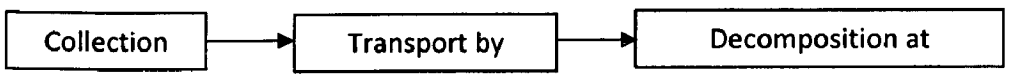
6.17 Domestic Waste:-

The waste produced contains mostly the bio drgradable waste and non-biodegradable waste or recyclable waste containing papers, card board, broken pieces of glass,ceramics etc will be taken by rag-pickers.They will be recycled in the gray market.

6.18 Cycle of Recyclable Waste:-



6.19 Cycle of Decomposable Waste:-



Hospital Waste: - This waste will be treated in the incinerator. The residue obtained is very dangerous in nature like radioactive matters. The residue has to be treated with special precaution.

Industrial Waste & Constructional Debris:- Industrial waste is mostly of recyclable nature.

6.20 Findings

1. The system of door-to-door collection of waste is not yet adopted and Street sweeping is the main method of waste collection.
2. The MMC has 28.5 hectares of land for waste disposal which is situated 12 kms away from the city. The waste is disposed off at the landfill site in orthodox method of dumping.
3. Storage of waste at source is not fully taking place as people prefer to dispose off the waste as and where it is generated.
4. Segregation of recyclable wastage is not yet adopted and often found mixed with garbage disposed at different places.
5. About 478 MT of SW is generated in the city per day. This is collected through street sweeping and from the community waste storage sites.
6. The efficiency of the collection mechanism of municipal solid waste is low, as only 60-70% of the solid waste generated is being collected and disposed off.
7. The street sweeping is done by teams, each team comprising of 4 members, out of them one sweeps the street, other cleans open drains and the third one picks up the waste in the cart, while the fourth pulls the cart.
8. Transportation of the waste is done through various vehicles like tractors, mini-trucks, trolleys, refuse compactors and dumpers etc. No transportation is done on public holidays and sundays.
9. The mechanism also lacks in the synchronization between the collection storage and transportation of MSW.
10. The method of disposal of solid waste is not scientific as per MSW Rules, 2000 for disposal of next 30 years
11. The solid waste is not at all segregated as organic and other wastes.
12. The MMC doesn't have a biomedical waste disposal system.
13. Bihar State Agro Development Corporation has setup a compost plant of 125 MT per day capacity on a plot adjoining the landfill site.

PERSPECTIVES OF SOLIDE WASTE MANAGEMENT

7.1 INTRODUCTION

Municipal solid waste management (MSWM) encompasses planning, engineering, organization, administration, financial and legal aspects of activities associated with generation, storage, collection, transfer and transport, processing and disposal of municipal solid wastes (household garbage and rubbish, street sweepings, construction debris, sanitation residues, etc.) in an environmentally compatible manner adopting principles of economy, aesthetics, energy and conservation (Tchobanoglous 1993).

The explosion in urban population is changing the nature of solid waste management in developing countries from mainly a low priority, localized issue to an internationally pervasive social problem.

India, the world's second highest populated country with population exceeding a billion and one of the fastest urbanizing countries, is a land of physical, climatic, geographic, ecological, social, cultural and linguistic diversity. The annual rate of growth of urban population in India is 3.09%. The proportion of population living in urban areas has increased from 17.35% in 1951 to 26.15% in 1991(CPCB, 1999). The number of Class I cities with population exceeding 1,00,000 has increased from 212 to 300 during 1981 to 1991 (CPHEEO,2000). It is interesting to note that as much as 65.2% of the urban population is living in these Class I cities. India has achieved multi-faceted socio-economic progress during the last 55 years of its independence. However, in spite of heavy expenditure by the Civic bodies, the present level of service in many urban areas is so low that there is a threat to the public health in particular and the environmental quality in general (Supreme Court Committee Report, 1999).

7.2 WASTE GENERATION AND ITS CHARECTERISTICS

The municipal authorities in most of the Indian towns do not weigh the refuse vehicles regularly but estimate the quantities on the basis of 'number of trips made by the collection vehicle'. Data base on solid waste generation/ collection is seldom maintained. It is estimated that solid waste generated in small, medium and large cities and towns in India is about 0.1 kg, 0.3 – 0. 4 kg and 0.5 kg per capita per day respectively. Studies carried out by National Environmental Engineering Research Institute (NEERI) indicated that the per capita generation rate increases with the size of the city and varies between 0.3 and 0.6 kg/d. In the metropolitan areas, values up to 0.5 kg / capita / day have been recorded. The estimated annual increase in per capita waste quantity is about 1.33% per year.

The physical composition of the waste is obtained as a percentage of the different constituents. The paper content generally varies between 1.0 and 6.0% and increases with the increase in population (Boyar 1996). The quantity of waste paper in India, is much less, as even the quantity thrown away is picked up by people for its use as a fuel and also for packaging of materials / food sold by roadside hawkers. The plastics, rubber and leather contents are lower than the paper content, and do not exceed 1% except in metropolitan cities. The metal content is also low, (less than 1%). These low values are essentially due to the large scale recycling of these constituents .Paper is recycled on a priority basis while plastics and glass are recycled to a lesser extent.

7.3 LEGAL AND INSTITUTIONAL FRAMEWORK

A National policy and legislation for Municipal Solid Waste Management, titled the Municipal Solid Waste (Management and Handling) Rules, was notified in 2000 with an implementation schedule as given in Table7.1. (MoEF, 2000). The Civic bodies have the responsibility to enforce these Rules. As per these Rules a wide spectrum of functions are to be undertaken by them. The major functions include

- Prohibiting littering of streets
- Organizing house to house waste collection
- Conducting awareness programmes to disseminate information to public
- Providing adequate community storage facilities
- Use of colour code bins and promotion of waste segregation
- Transport of wastes in covered vehicles
- Proeessing of wastes by adopting an appropriate combination of composting, anaerobic digestion, penalisation etc.
- Upgradation of the existing dump sites and disposal of inert wastes in sanitary landfills

As per the Rules, the citizens are responsible for--

- Segregation of wastes at source
- Avoid littering of streets
- Delivery of wastes in accordance with the delivery system notified by the respective Civic body.

Table-7.1:- Implementation Schedule for Municipal Solid Waste Disposal in India (MoEF, 2000)

Compliance Criteria	Cities/towns with population			
	More than 10 lakhs	1 to 10 lakhs	0.5 to 1.0 lakhs	Less than 0.5 lakhs
Setting up of suitable composting facilities to make use of waste	by 31. 12. 2001 or earlier	by 31.12.2001 or earlier	by 31.12.2001 or earlier	by 31.12.2001 or earlier
Monitoring of disposal facilities set up to meet laid down standards	Once in four months on yearly basis	Once in six months on yearly basis	Once in a year	Once in a year
Existing landfill sites to be improved as per existing provisions of the rules	by 31. 12.2001 or earlier	by 31.12.2001 or earlier	by 31.12.2001 or earlier	by 31.12.2001 or earlier
Identification of landfill sites for future use	by 3 1.1 2.2000 or earlier	by 31.12.2000 or earlier	by 31.12.2000 or earlier	by 31.12.2000 or earlier

Source: Center for Environmental Studies, Anna University, Chennai, India

Most Civic bodies are yet to take initiatives to comply with the Rules citing financial constraints and the deadline for improving the dumpsites have already passed on March 31, 2001. There are separate legislations addressing issues related to management and handling of hazardous and bio medical wastes. The Government has also banned the use of recycled plastic and non-permissible colours in production of polythene bags for food packaging. Production of polythene bags less than 20 microns has also been banned. But this actually increases the use of more virgin plastics. Although the polythene bags constitute 5% of the total volume of MSW, the municipalities are being awfully disturbed by the havoc created by the polythene bags. Many of the municipalities are seeking legal provisions to ban them.

7.4 PRESENT MANAGEMENT PRACTICES

Waste generated at households is generally accumulated in small containers (often plastic buckets) until such time, that there is sufficient quantity to warrant disposal into community bins Containers used for household storage of solid wastes are of many shapes and sizes, and are fabricated from a variety of materials. Waste segregation at source is not practiced.

The community storage system is usually practiced in majority of towns and cities in India. Individuals deposit their waste in bins located at street corners and at specific intervals. Community storage may reduce the cost of waste collection, and can minimize problems associated with lack of on site storage space. However, unless these community storage arrangements are conveniently located, householders tend to throw their wastes into the roadside gutters for clearance by street sweeping crews. Even where storage arrangements are conveniently located, wastes tend to be strewn around the storage area, partly due to indiscipline and partly as a result of scavenging of the wastes by rag-pickers and stray animals. Due to the absence of adequate storage capacity for the refuse generated and poor discipline among the generators, the wastes are continually dumped on the road (Boyar 1996).

Different types of vehicles, varying from bullock carts to compactors, are used for waste transportation. However, the general-purpose open body trucks of 5 to 9 tones capacity are in common use. In smaller towns, tractor-trailers are used despite being noisy and inefficient. In a few cities, compactor vehicles are also being used. The waste is transported mostly by municipal vehicles; though, in some large towns, private vehicles are also hired to augment the fleet size. The maintenance of the vehicles is carred out in the general municipal workshop along with other municipal vehicles where the municipal refuse vehicles receive the least priority. Most of these workshops have facilities for minor repairs only.

Although preventive maintenance is necessary to maintain collection fleet in proper operating condition, neglect of preventive maintenance is a common situation. Transfer stations are in place only in a few metropolitan cities.

The present system of MSWM can be depicted by Figure-7.1

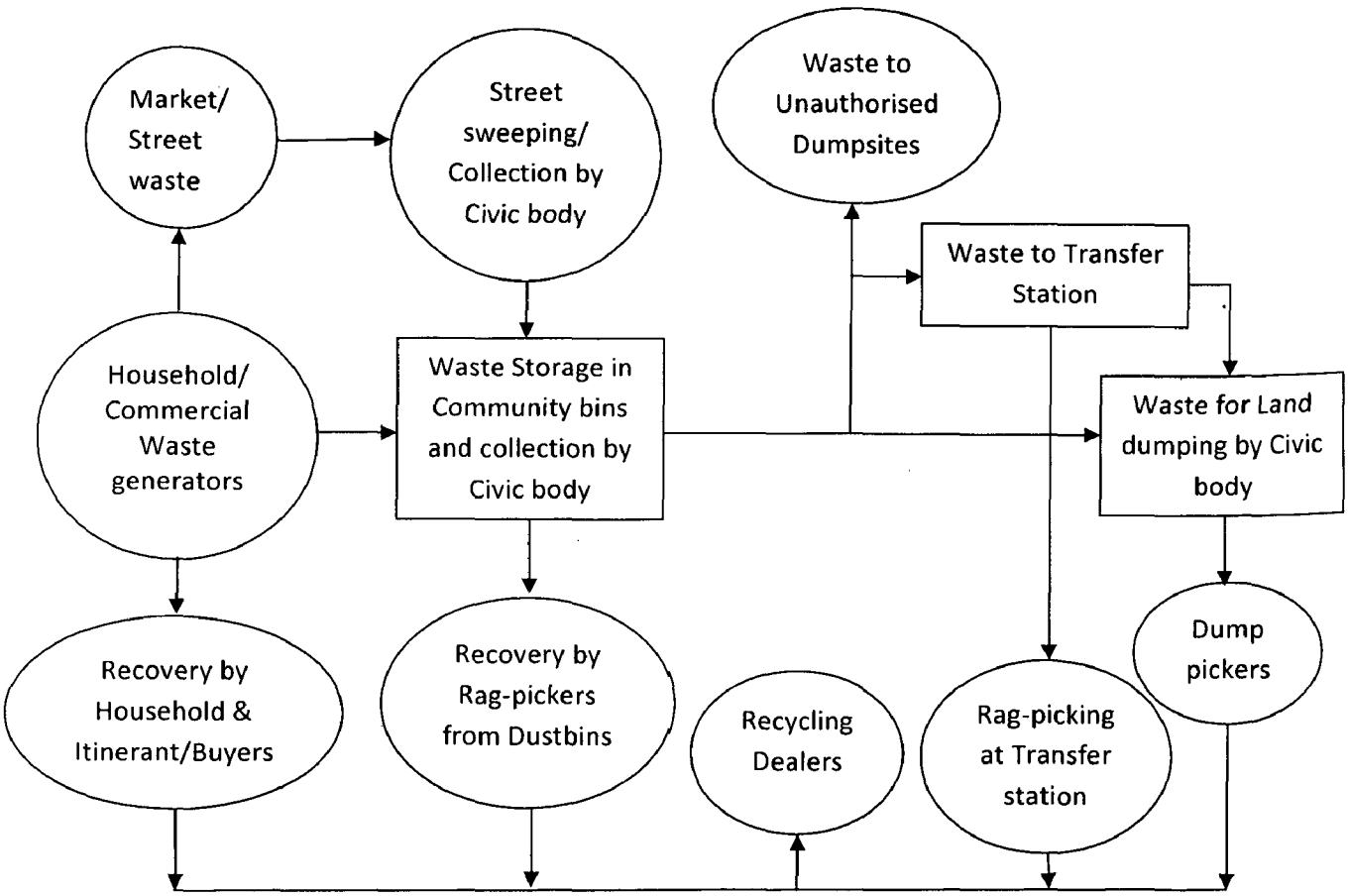


Figure-7.1 Schematic Representation of solid waste management practice in india

Commercial sector like shops, offices, hotels, etc all use the community waste bins and their wastes are also collected along with the household wastes except in a rare number of commercial complexes where they pay a negotiated fee to the Municipal Authorities for collecting waste from their premises. Most of the shops do not open before 9 am and so do not put their waste out until that time, which will be left mostly on the street until the next day's collection. In short, even if there is regular collection services, wastes are always seen on the streets.

CHAPTER – 7 PERSPECTIVES OF SOLIDE WASTE MANAGEMENT

Several thousands of urban dwellers in India, make their living upon wastes in many small industries using plastics, tin cans, bottles, bones, hair, leather, glass, metal, etc recovered from MSW. All metals, unsoiled paper, plastics, glass, cardboard etc are readily marketable and hence recycled by householders themselves or rag-pickers. By the time waste reaches the community bins, it contains every little in the way of recyclable and consists mainly of vegetable / fruit peelings, scraps of soiled paper and plastic, used toiletries etc. (Jalan et al, 1995).

The larger proportion of organic matter in MSW indicates the desirability of biological processing of waste. Though composting was a prevalent biological processing practice in India, in the past due to non-availability of adequate space in the urban centers and poor segregation of wastes, composting has been discontinued as a practice. Recently efforts are being taken to popularize waste segregation and composting. Characteristics of the Indian MSW bring out the fact that a self-sustaining combustion reaction cannot be obtained in a majority of Indian MSW and auxiliary fuel will be required to aid waste combustion. An incineration plant of 300 tpd capacity set up at Delhi, has not been operational due to low calorific values encountered. A biomethanation plant was proposed at Pune and Mumbai, but its full-scale operation is yet to begin and viability is yet to be proven. A project for producing 105 tpd fuel pellets from municipal solid wastes (MSW) in Hyderabad has been installed. Work on a four megawatt MSW based power plant in Nagpur has commenced. A few other projects for generation of power from MSW in cities such as Chennai, Lucknow, etc. have matured. (Dhussa and Tiwari, 2000).

7.5 NATIONAL PLAN FOR MSWM

Considering the present status of MSWM in the country, the committee constituted by the Supreme Court of India has summarized the elements of MSWM. In a flow chart as depicted in Figure-7.2

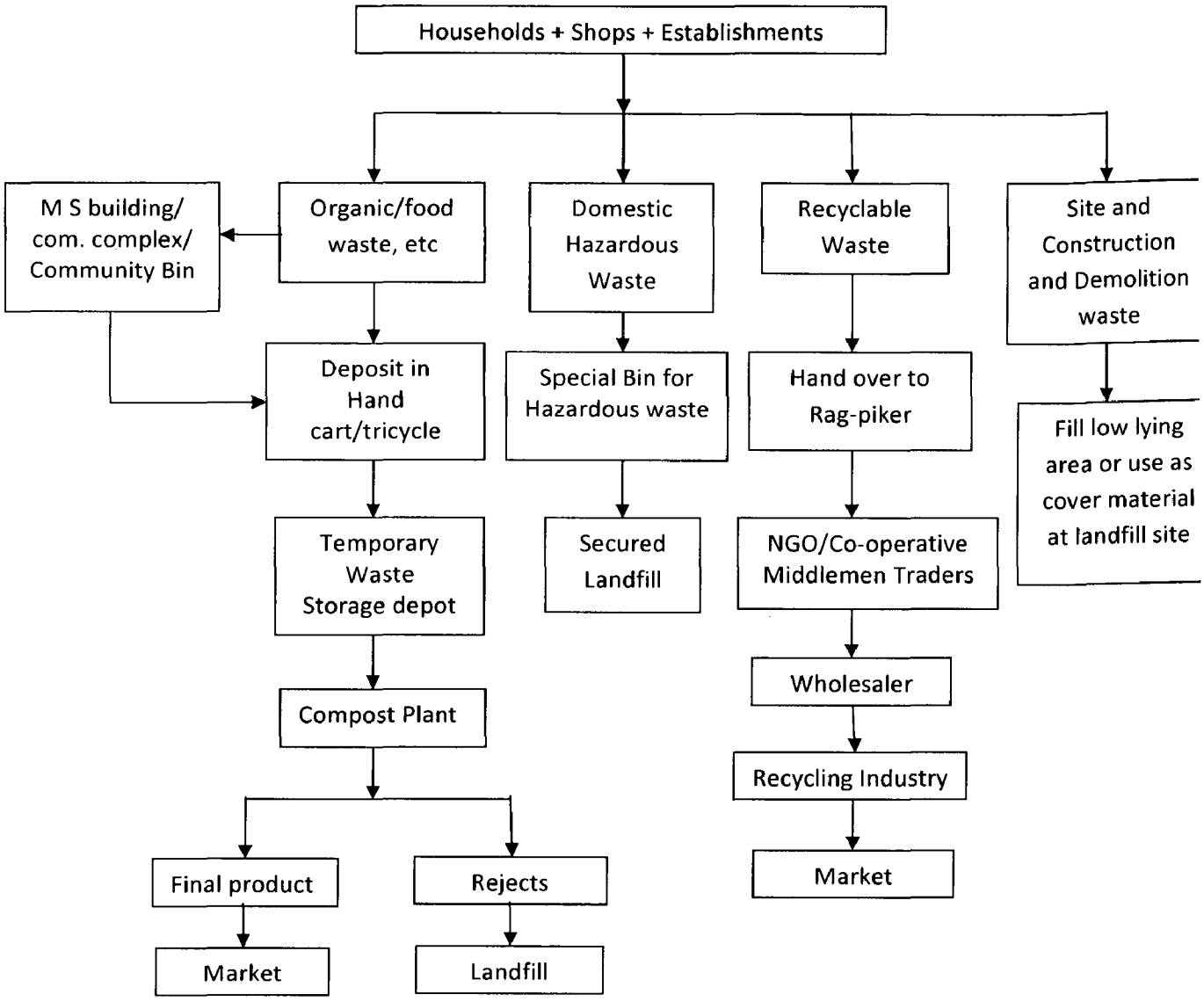


Figure :-7.2 Recommended Flow Chart Of Municipal Solid Waste In India

Source: Supreme Court Committee Report, 1999.

CHAPTER – 7 PERSPECTIVES OF SOLIDE WASTE MANAGEMENT

Several attempts are underway to improve better management of municipal solid wastes (Singhal and Pandey, 2001). Deliberation on administrative, technical, financial and legal issues are being considered for the feasible means of management. Foreign investment in garbage management has been appreciated and modalities on bilateral collaboration with willing countries have been explored. Some of the initiatives in this direction included constitution of a National Waste Management Council (1990), formulation of a National Strategy Paper on MSWM prepared by National Environmental Engineering Research Institute on behalf of the Ministry of Urban Affairs and Employment, publication of a Manual on Municipal Solid Waste Management (CPHEEO, 2000) and implementation of Municipal Wastes (Management and Handling) Rules (2000) under the Environmental Protection Act by coordinated efforts of Municipal Agencies, Ministry of Environment and Forests, Government of India. Central Pollution Control Board (CPCB) and State Pollution Control Boards (Indrani, 2002). The recommendation of the Expert Committee (1999) constituted by the Honorable Supreme Court of India points towards the directions in which the country is moving towards improvement of MSWM. Some of the important recommendations are:

- Ban on throwing wastes on streets and levy of administrative charges from those who litter the streets
- Segregation of wastes at source
- Doorstep collection of wastes
- Sweeping streets on all days of the year
- Work norms for sweeping of streets
- Provision of litter bins at public places
- Abolition of open waste storage sites and manual collection.
- Conversion of organic wastes into compost

- Upgradation of existing dumpsites
- Siting, construction and operation of sanitary landfills
- Institutional strengthening and capacity building
- NGO participation in SWM practices
- Public awareness strategy
- Financial strengthening of local bodies

GLOBAL WASTE MINIMIZATION: A NEW APPROACH TO SOLID WASTE MANAMEMENT

8 .1 Minimization of Waste by Process Design

Waste is the ever-present curse of modern civilization. Its creation in waste volumes seems inevitable and, once created, it must be disposed off safely. But is it inevitable? If there is no waste, there is no problem with waste. Our subject is waste management, but the best management approach is to manage affairs so that there is no waste to manage. That is of course an impossible dream, but the proper management of waste being produced should be minimized, if not totally eliminated. The production of waste can be drastically reduced in many instances. There are two main methods of approach to initial waste reduction; designing plants so that less waste is produced; and reusing or recycling such waste that is produced. During international seminars and conferences on waste minimization, whilst it was felt that much remains to be done with respect to waste treatment, by seeking out more efficient and cost-effective methods, yet a more direct approach was through waste minimization. The change in emphasis over the past 15 years was highlighted thus-

Predominant Method: -

fifteen years ago:	safe landfills
five years ago;	safe treatment
today:	waste minimization,

Unfortunately, all the regulations relating to waste seem to be based on the premise that wastes in unavoidable.

There are no regulations prohibiting in any way the initial production of waste, only regulations stating what is to happen to it once the problem has been created; a more fundamental issue is that attempts should be made and encouraged to reduce that volume of waste which has to be disposed off.

CHAPTER-8 GLOBAL WASTE MINIMIZATION: A NEW APPROACH TO SOLID WASTE MANAGEMENT

There is no doubt that efforts to reduce and minimize waste can bring substantial dividends: not only is there a substantial financial inducement, but there are also other benefits that cannot be evaluated in direct monetary terms. For example, the 'image' of

a company and its public relations will both improve. Furthermore, if, for instance, the volume of waste produced was halved, the problems associated with its disposal would be more than halved.

8 . 2 Waste is generated at the Drawing Board

Prevention is always better than cure, so that when plants are being built, *waste creation* or better *waste elimination* should be considered before waste treatment and disposal. This may well mean seeking an alternative process, an approach that may be time-consuming, but ultimately very rewarding. The problem must be attacked at its root and this could lead to its disappearance.

Substitute *'waste prevention'* for *'safety'* and the advice is pertinent to the present subject. Engineers-to-be should be brought to realize that they, personally, are responsible for the outcome of their work and its proper functioning. Howsoever incidental and minor their work may appear to be, they may well have the lives of people, perhaps many people, in their hands. Waste elimination has an importance in this context equal to plant safety, especially when the waste happens to be hazardous or toxic.

There are meaningful ways of waste reduction. A waste by-product can be reintroduced as raw material; production processes and operations can be changed; raw materials can be substituted; products can be reformulated; inventories of dangerous materials can be minimized.

Given the way in which companies are currently organized to deal with environment problems, and the manner in which economic analysis is applied when evaluating alternatives, there is an in-built bias against waste reduction.

8 .3 The Role of Waste Minimization

*What is the difference between waste minimization and waste reduction.*To have waste reduction as an objective is to seek to reduce the volume of waste produced. A realistic and serious waste reduction programmer must start with a step-by-step waste audit and the compilation of the waste reduction possibilities. These are ranked in order that the optimum option may be selected. An extremely useful checklist has been provided in this context by Formm. the success of such a programme can be evaluated in terms of quantity of waste generated per unit of production, and the audit team must have a good understanding of the process and full cooperation from the plant operators.

Non-waste technology is exactly that: no waste at all is generated. It is an issue of worldwide importance and has been regarded as significant enough to merit being defined by the United Nations Economic Commission for Europe (UNECE) thus:

The practical application of knowledge, method and means, so as-within the needs of man- to provide the most rational use of natural resources and energy, and to protect the environment.

It is still usually uneconomic. As we survey present trends, we see the development of a non-waste technology to be an imperative. The three key factors leading to this conclusion are:

a. raw material resources are finite and are rapidly depleting,

b. there is an energy crisis in terms of both availability and price, and

c. there is serious environmental pollution.

The non-waste technology should have an impact on these three key factors as under;

I. Materials: Products should be designed for long life and conservation.

II. Energy: Every means should be adopted to avoid loss (e.g. by insulation)

and to increase efficiency.

III. Pollution: Non-polluting processes should be used, and recycling done where waste is unavoidable.

8.4 A Non-Waste Value System

Waste is enormously wasteful. It leads not only to pollution today, but to material shortages tomorrow. The age-old saying *waste not, want not* is as valid in the affluent society of today as it ever was. The very existence of society as we now know is threatened by the continuing waste of precious, scarce resources. If the present industrialized society is to survive, it must become a non-waste society with a non-waste economy using non-waste technology and above all, a non-waste value system.

- 1 kg. of animal protein takes 10 times as much energy to produce as does 1 kg. of vegetable protein
- Air transport requires at least a 100 times as much energy as water transport per passenger or per km.
- A car requires 30 times the energy of a bicycle per passenger or per km.

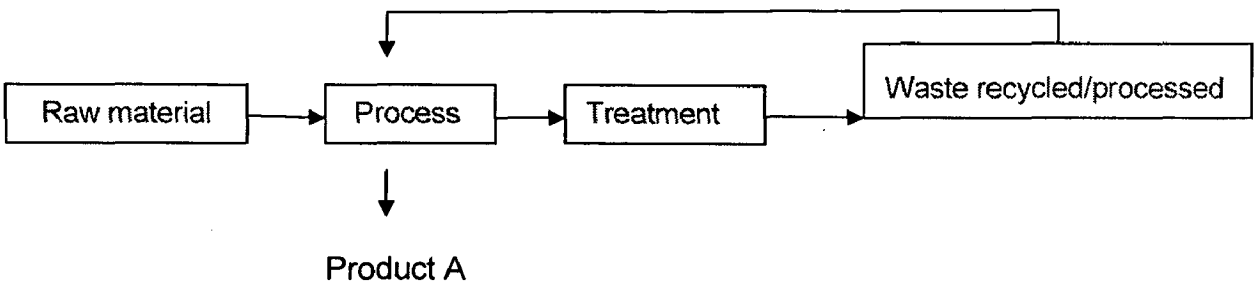


Figure 8.1: Zero Waste Technology

CHAPTER- 8 GLOBAL WASTE MINIMIZATION: A NEW APPROACH TO SOLID WASTE MANAGEMENT

The recycling of waste, whatever its from, is very sound approach to a mounting problem. The immediate and most direct answer to the problem of the growing mountain of waste is to recover and recycle to the maximum extent possible. Many basic materials, such as metals, paper, and glass, can be separated out and recycled to the advantage of us all. At the same time the natural raw materials - mineral ores, timber and limestone respectively - are being conserved.

'The volume of plastics had increased sub-statically, largely at the expense of the wastepaper and glass.

Industrialized countries can be expected to show a very similar pattern in relation to their domestic waste. Recycled materials are used for the manufacture of cans, bottles, paper and the like. Solid residuals can be used to generate energy in the form of steam, gas or electricity an -aspect discussed earlier. The recycling of metals, in particular, can lead to enormous savings in energy as compared with the initial manufacture. Both air and water pollution will. be reduced by recycling, and less water will be used.

There are profits to be made from waste recycling. Whilst the re-use of waste has been promoted as good economic sense for the public, it can also be good business for those who engage in it. The ever-increasing cost of waste disposal and the fact that there are profits to be made from recycling have fuelled the current boom.

Table: - 8.1 Reductions achieved (%)

	Aluminum	Steel	Paper	Glass
Energy use	90-97	47-74	23-74	4-32
Air pollution	95	85	74	20
Water Pollution	97	75	35	-
Water use	-	40	8	50

Paper recycling has been encouraged by promoting the motto 'recycle your paper, save a tree'. The disposal of old tires has posed a serious problem for many years. Now they are being ground up to form 'crumb rubber' which then can be used in a better durable product than does virgin rubber. Recycling becomes attractive as the cost of waste disposal by other means rises. Whilst it is profitable it will be pursued. It minimizes the damage that waste does to our health and the environment, but that will never happen. The good environment could well always prevail

There is every possibility that at least half of the domestic waste currently being generated could be recycled, the potential is there, but to achieve such a degree of recycling requires considerable planning and intensive effort. Paper, for example, will lose its value rapidly when mixed with organic food waste. Glass and metals are less vulnerable to degradation in this way, but they still need to be segregated. Organic waste, if destined for composting, must be free of inorganic substances toxic to plant life. In general, the nearer the recoveries process it to the sources of the waste, the less sorting and processing will be required before.

Table 8.2 The Use Being Made of Recycling In Some of the Major Industrial Countries

Percentage Recycled (in 1985)			
	Aluminum	**Paper**	**Glass**
United states	28	27	10
United kingdom	23	29	12
Japan	32	48	-
The netherlands	40	46	53
West germany	34	40	39

In considering the impact of recycling, the most significant aspect is the reduction in the demand for the basic raw materials and the reduction in pollution from the manufacturing process. For instance, the recycling of a tonne of aluminum apart from the enormous saving in electrical energy, eliminates the need for four tonnes of bauxite and 700 kg of petroleum coke, whilst the emission of the air-polluting aluminum fluoride is reduced by some 35kg. Paper is another case. Where the impact of recycling on the environment could be quite dramatic.

Recycling paper not only spares millions of hectares of trees from felling, but also conserves energy and reduces water pollution. If only half of the paper used in the world

today were recycled that would not only meet a substantial part of the demand for newspaper but also preserve nearly 8 million hectares of forest land. There are many plastic products that can be modified to make them degradable and this is obviously a very desirable and approach. There is a new potential for degradable plastics in the light of the growing impact of environmental factors and coming worldwide legislation which is likely to present obstacle to the future growth of the plastic industry.

8.5 Efforts in Developing Countries

Effort in this direction is not so well organized in the developing countries.

Recycling can make a very substantial contribution towards minimizing the volumes of waste that have to be disposed off Everyone seems convinced that recycling is the way to solve the problem associated with waste disposal.

Countries such as West Germany, The Netherlands and Japan, who do not have an abundance of raw materials and are also limited for space, have used recycling for many years. Most of the recycling takes place with municipal waste with more than 50 per cent of such waste being recycled. Waste once deposited is normally the legal property of the municipality, but exemptions to this rule have been made to facilitate recycling. For instance, a day is nominated for surplus or unwanted furniture and other household goods to be placed at the roadside, and anyone is at liberty to remove such items for their own use before the council cleaners come along. The main factor is the order to win their cooperation. It is recognized that what may be waste and not wanted by one may be riches for another.

This is almost always the case as we have found by personal experience. One of us picked up a discarded portable typewriter in the United States in this manner took it home and had it serviced. It is still in excellent condition after five years for further use.

8.6 Recycling Plastic

One of the biggest obstacles to the recycling of plastic waste has been that the various types of plastic waste cannot be mixed with one another: the chemical reactions that ensue cause too many processing difficulties. However, techniques have now been developed whereby incompatible plastic can be blended and still turned in to useful products. A Belgian company, Advanced Recycling Technology, has developed an extruder which will blend a range of plastic materials such as polyvinyl chloride (PVC), polyethylene terphthalate (PET) and polystyrene (PS). The mix can then be formed into stable modeled products. Over a dozen such plants based on this

extruder technology are currency in use across Europe and in the United States. The extruder melts the mixture of plastics together, and this can then be modeled as appropriately. The product has wood-like properties; it can be nailed, screwec into, cut and planed with standard woodworking equipment. It is indeed better than wood in many applications, since it is water-resistant, rot-and bacteria-proof, and resistant to salt water and chemicals. Indeed, the very properties which make it so difficult to dispose off are of great value in re-use. The material will not splinter or split, withstands freezing and thawing and can absorb shocks. One use has been in the manufacture of fencing posts, and it seems that posts placed in the ground five years ago have remained upright and rot-free, requiring no maintenance.

CONCLUSION, RECOMMENDATIONS, PROPOSALS AND GUIDELINES

9.1 Conclusion

The explosion in world population is changing the nature of solid waste management from mainly a 'low priority localized issue' to an 'internationally pervasive social problem'. Risks to the public health and the environment due to solid waste in large metropolitan areas are becoming intolerable. The paper has summarized the salient features of the current scenario of Municipal Solid Waste Management in Muzaffarpur city in particular and in India in general and endeavors to suggest future directions for improving the situation.

The solid waste management in Muzaffarpur city is not functioning properly. It is a matter of serious concern for the city. Every year, in the rainy season infectious diseases spread due to inefficient Solid waste Management and a significant number of people fall ill.

Today Muzaffarpur is considered as one of the 'unclean' cities of the country. The bad image of the city hinders its development.

Today the Muzaffarpur Municipal Corporation (MMC) has total 49 wards with a population of 3,51,284.75 (2009). Its area is 32.316 (sq km). There is separate department for the management of solid waste in the MMC. In each division this work is done under the supervision of a sanitary inspector. Muzaffarpur is growing at the rate of 15.18 % decadal growths or even more (there is no record of unauthorized construction and population). It is observed that the population of this city went on increasing but the number of sanitary staff of the MMC went on decreasing.

The municipal area of Muzaffarpur being the study area of this project, the paper gives recommendations, proposals and guide lines for the improvement of the existing SWM system in Muzaffarpur. This will not only improve the SWM system including collection, transportation, segregation and disposal of the waste but also improve the environmental conditions of the city. The city will have a healthy look and the image of the city will improve and thus it will become one of the 'clean' cities of the country. When the solid waste management of the city becomes better, the hygienic condition of the city will also improve and the city's environment will become healthy thereby enhancing the aesthetics and the image of the city.

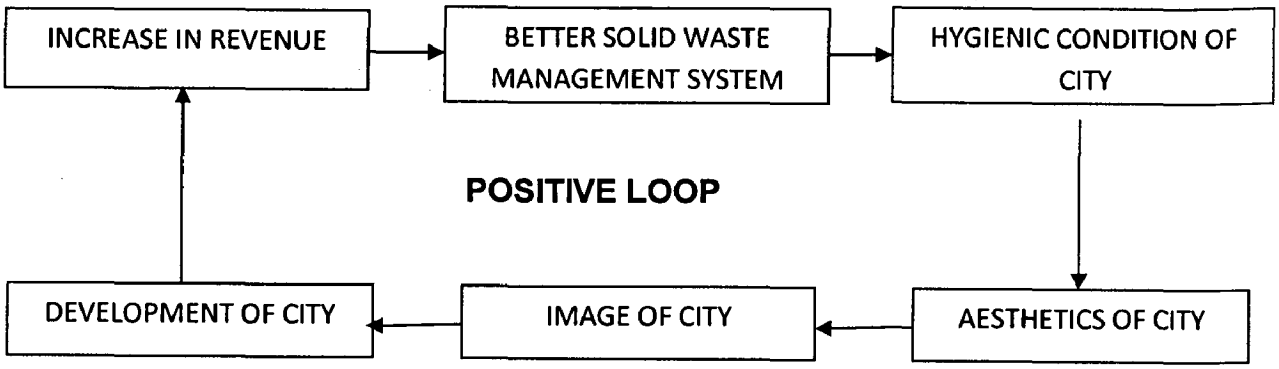


Figure 9.1 shows the relationship between the solid waste management and development of the city.

The aforesaid successive steps will better the image of the city. The better image of the city will attract businessmen, investors and entrepreneurs. from outside. Business and industrial activities will increase in the city. This will result in the overall growth of the city and the revenue generation in the city will increase. The income of the MMC will also increase and it will be able to spend money for the infrastructural facilities in the city.

As noted earlier, successful MSWM depends on adequate financing, enabling legislation and a supporting institutional and policy environment. In many cases this will require changes in the way government institutions currently operate and will necessitate recognition of the importance of effective MSWM for the city's sustained development.

9.2 Recommendations

9.2.1 Storage of Municipal Solid Wastes

Municipal authority shall establish and maintain storage facilities in such a manner as these do not create insanitary conditions and thus unhygienic environment around it. Following criteria shall be taken into account while establishing and maintaining storage facilities, as:-

(a) Storage facilities shall be created and established by taking into account quantities of waste generation in a given area and the population densities. A storage facility shall be so placed that it is accessible to users.

(b) Storage facilities to be set up by municipal authority or any other agency shall be so designed that wastes stored are not exposed to open atmosphere and shall be aesthetically acceptable and user-friendly.

(c) Storage facilities or 'bins' shall have 'easy to operate' design for handling, transfer and transportation of waste. Bins for storage of bio-degradable wastes shall be painted green, those for storage of recyclable wastes shall be printed white and those for storage of other wastes shall be printed black.

(d) Manual handling of waste shall be prohibited. If unavoidable due to constraints, manual handling shall be carried out under proper precaution with due care for safety of workers.

9.2.2 Collection of Municipal Solid Wastes

1. Littering of municipal solid waste shall be prohibited in city area notified by the State Government. To prohibit littering and facilitate compliance, the following steps shall be taken by the Municipal Authority, namely:-
   (a) Organizing house-to-house collection of municipal solid wastes through any of the methods, like community bin collection (central bin), house-to-house collection, collection on regular pre-informed timings and scheduling by using bell ringing of musical vehicle (without exceeding permissible noise levels)
   (b) Devising collection of waste from slums and squatter areas or localities including hotels, restaurants, office complexes and commercial areas.
   (c) Wastes from slaughter houses, meat and fish markets, fruits and vegetable markets, which are biodegradable in nature, shall be managed to make use of such wastes.
   (d) Bio-medical wastes and industrial wastes shall not be mixed with municipal solid wastes and such wastes shall follow the rules separately specified for the purpose.
   (e) Collected waste from residential and other areas shall be transferred to community bin by hand-driven containerized carts or other small vehicles.
   (f) Horticultural and construction or demolition wastes or debris shall be separately collected and disposed off following proper norms. Similarly, wastes generated at dairies shall be regulated in accordance with the State laws.
   (g) Waste (garbage, dry leaves) shall not be burnt.
   (h) Stray animals shall not be allowed to move around waste storage facilities or at any other place in the city and shall be managed in accordance with the State laws.

2. The municipal authority shall notify waste collection schedule and the likely method to be adopted for public benefit in a city.

3. It shall be the responsibility of generator of wastes to avoid littering and ensure delivery of wastes in accordance with the collection and segregation system to be notified by the municipal authority.

4. Increased efficiency in primary collection of domestic solid waste from households and small commercial establishments, to at least 85% of households in high-density areas, and 60% in the lower density (generally) sub-urban areas, with minimize manual handing.

9.2.3 Transportation of Municipal Solid Wastes

Vehicles used for transportation of wastes shall be covered. Waste should not be visible to public, nor exposed to open environment preventing their scattering. The following criteria shall be met, namely:-

1. The storage facilities set up by municipal authority shall be daily attended for clearing of wastes. The bins or containers wherever placed shall be cleaned before they start overflowing;

2. Transportation vehicles shall be so designed that multiple handling of wastes, prior to final disposal, is avoided.

9.2.4 Processing of Municipal Solid Wastes

Municipal authority shall adopt suitable technology or combination of such technologies to make use of wastes so as to minimize burden on landfill. Following criteria shall be adopted, namely: -

1. The biodegradable wastes shall be processed by composting, vermicomposting, anaerobic digestion or any other appropriate biological processing for stabilization of wastes.
2. Mixed waste containing recoverable resources shall follow the route of recycling. Incineration with or without energy recovery including pelletisation can also be used for processing wastes in specific cases. Municipal authority or the operator of a facility wishing to use other *state of the art* technologies shall

approach the Central Pollution Control Board to get the standards laid down before applying for grant of authorization.

9.2.5 Disposal of Municipal Solid Wastes

Land filling shall be restricted to non-biodegradable, inert waste and other waste that are not suitable either for recycling or for biological processing. Land filling shall also be carried out for residues of waste processing facilities as well as pre-processing rejects from waste processing facilities. Land filling of mixed waste shall be avoided unless the same is found unsuitable for waste processing. Under unavoidable circumstances or till installation of alternate facilities, land-filling shall be done following proper norms.

9.2.6 Institutions

1. Muzaffarpur Municipal Corporation
2. Private sector
3. Increased private sector and community participation
4. For the private sector involved in solid waste management, incentives shall be introduced for improved performance.

Awareness campaigns shall be taken up in all slums and through the media about waste minimization, source segregation, healthy ways of storage at source and reuse. This is aimed at increasing level of community participation.

9.2.7 Segregation of Municipal Solid Wastes

In order to encourage the citizens, municipal authority shall organize awareness programmes for segregation of wastes and shall promote recycling or reuse of segregated materials. The municipal authority shall undertake phased programmes to ensure community participation in waste segregation. For this purpose, regular meetings at quarterly intervals shall be arranged by the municipal authority with representatives of local resident welfare associations and non-governmental organizations.

Source segregation of solid waste is practiced in the city and shall be effectively increased and materials of value shall be segregated for recycling and income generation. Waste material from demolition sites such as timber, masonry and other processable wastes shall be diverted to the transfer stations and reused. In consultation with community development groups, creation of rag pickers' societies shall be initiated in slums. Based on a survey of processable and recyclable wastes being generated and the various reuses they can be put to, such societies shall be facilitated in contacting all such units and industries that can reuse them, thereby creating a corporation assisted rehabilitation and employment generation program.

1. Improved and safer working conditions for municipal waste operators.
2. Improved final treatment and disposal of domestic solid waste.
3. Improved management of the process in accordance with the recommendations of the Supreme Court.

9.3 Proposals

Proposals for the Improvement of SWM System are:

1. The main roads' sweeping can be given to the private contractors.
2. An Incineration plant has to be established to process the hazardous waste. Nursing homes, hospitals, pathological labs etc.throw their bio-medical waste in the open spaces around them. They must be directed to use the Incineration facility.
3. Bio degradable waste can be directly decomposed (by composing) and can be used as fertilizer. Buildings having large campus can decompose the bio-degradable SW in their campus.
4. The aesthetics and the hygienic condition of the city should be made the matter of common interest of the people by highlighting this topic in the media.
5. Civic sense in the citizens should be developed so that they don't throw the SW besides the road, in the vacant land, parks and play grounds.
6. In return, the establishment maintaining the cleanliness can put their sign-boards in that open space as advertisement. MMC can give them the reward of tax incentives also.
7. The owners of the private land should be fined if they allow any undesirable activity in their plots.
8. Use of open spaces for the storage of non-biodegradable type of material should be banned.
9. Garage owners leave their old vehicles, old tires besides the road. They should be fined if doing so.
10. Shopkeepers, hoteliers, butchers, garage owners, vegetable sellers, and hawkers should be warned specially and given direction to keep their own garbage bins for the solid waste they produce.

11. The public representatives (MLAs, MPs, etc) should be persuaded/convinced/motivated to take interest in keeping the open spaces clean. From their fund they can provide garbage bins where MMC cannot provide the bins.

12. Informal group activities should be allowed but they should not be allowed to litter their waste anywhere.

13. Decentralized neighborhood, or business-scale composing - Such facilities can provide a waste management opportunity to a small group of people at a relatively low cost. Small-scale composting uses the wastes of a number of households, shops, or institutions; the composting is done on unused land, beside community gardens, or in parks.

14. In the residential colonies cattle owners keep their cattle in the open spaces which litter cow dung anywhere. Appropriate measures should be taken to curb this littering and proper disposal of dung should be ensured.

15. Animal feeding of the kitchen waste - vegetables or food waste can be given to the animal owners directly to feed the animals.

16. Slums should not be allowed to develop in the open spaces.

17. There is only one site for disposal of solid waste, so acquire new sites for disposal and treatment of solid waste, because the old site is situated towards the north of Muzaffarpur that is far away from the south of Muzaffarpur .

18. The reduction at the source can be done by putting two types of plastic buckets in the house one for bio-degradable waste and other for non-biodegradable waste. The non-biodegradable waste can be directly collected by rag pickers from the house. The rag-pickers can recycle the latter. In return of this the MMC can charge some nominal amount from the rag pickers. By this method the SW can be reduced at the source by 30 to 50 % and the problem of disposal can be solved to a great extent.

19. Collection efficiencies shall be improved through the provision of appropriate containers (of 1 m^3 and 4.5 m^3, depending on access and population density), using corporation sweepers and local community arrangements to convey domestic waste from household to the containers with minimized manual handing.

20. Improved transportation of waste should be carried by appropriate vehicles, minimizing manual handing. Compactor vehicles empty the waste mechanically from the 1 m^3 containers into the compactors, whereas dumper placer trucks collect the larger 4.5 m^3 containers for direct transport to the landfill site.

21 Improve final treatment and disposal of domestic solid waste, by the Construction and use of a sanitary landfill, being the least-cost option available for waste disposal.

22. Two types of garbage bins have to be provided at regular intervals:-

(a) Local garbage bins at the interval of 100 meters of 1 tonne capacity, Here people from the houses will come and throw the garbage.

(b) Community garbage bins at the interval of 500 meters of 4.5 tonnes capacity, The sanitary workers will collect the SW from the local garbage points and dump them in the community bins. From here tractors and trippers will pick up the SW to the disposal sites. This has to be placed on the wide and main roads to provide enough space for the movement of vehicles.

23. The industrial establishments, big shops, commercial units, govt. institutes, private institutes, shops, market complexes, etc. can be given the responsibility by the MMC to keep their surrounding areas clean.

24. In planned colonies, the housing societies can be held responsible for themaintenance of the open spaces of their area.

25. Increase the number of staff and number of vehicles to meet the requirements.

26. The required sanitary workers can be hired on contract basis also.

9.4 Guidelines

From all the studies, case studies and experience in the solid waste management inferences can be drawn now. For the improvement of the SW management in Muzaffarpur the following recommendations can be given:

(a) The Muzaffarpur municipal corporation (MMC) should ban throwing of SW on the roadside, especially in the commercial areas. Legal provisions should be made for that. Whosoever found guilty should be fined / punished.

(b) MMC should provide sufficient number of bins along the road.

(c) Segregation of the waste at site method should be adopted. Two bin collection systems should adopt in the residential and commercial areas as well as near nursing homes etc.

(d) The Muzaffarpur municipal corporation (MMC) should charge for the management of SW from the commercial establishments like industries, business units, shops, nursing homes etc.

(e) The accumulation of construction debris and construction material should be banned along the roadside.

(f) There should be co-ordination among the various govt. departments so that no department leaves its belongings along the roadside unattended. (eg: police department, telephone department and public works department, etc. leave their old vehicles unattended along the road side to rot.)

(g) MMC should increase the number of wards according to standards. It is also essential to reinforce the traditional practices of reuse and recycling in the society to keep the waste generation at the minimum. The various government and non-government agencies should promote such programmes at the community level to create awareness, and also to minimize waste production.

(h) The factories should be compelled to use zero waste technology in their factories to reduce the production of refuse from the factories.

(i) Factories should be encouraged to recycle the recyclable segregated waste as raw materials so that quantum of disposable waste could be reduced.

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ANNEXURE-I

GLOSSARY OF TERMS

Some of the words used and their connotations are reproduced below from IS 9569-1980. 'Glossary of Terms relating to Solid Wastes'

Aerobic - Able to live and grow only in the presence of free oxygen.

Afterburner - A device used to burn or oxidize the combustible constituents remaining in effluent gases.

Air - The mixture of gases comprising the earth's atmosphere.

Air, Stoichiometric - See Combustion Air, Theoretical.

Air, Under fire - Air that may be forced or induced in a controlled quantity and direction and is supplied below a grate and passes through a fuel bed.

Air Pollutant - A substance which when present in adequate amount adversely affects the environment.

Air Pollution - The presence in ambient atmosphere of substances, generally resulting from the activity of man, in sufficient concentration, present for a sufficient time and under circumstances to interfere significantly with comfort, health or welfare of persons or with full use or enjoyment of property.

Air Quality - The composition of air with respect to quantities of pollutants therein.

Air Quality Standards - The maximum acceptable pollutant concentration in the outside air that cannot be exceeded during a specified time in a specified area.

Alley Collection- Removal of solid wastes from containers placed adjacent to an alley.

Analysis, Proximate - Analysis of a solid fuel to determine its moisture, volatile matter, fixed carbon and ash content. Usually the fuel's heat value is also determined.

Analysis, Ultimate - The chemical analysis of a solid, liquid or gaseous fuel. In the case of solid fuel, the amount of carbon, hydrogen, sulphur, nitrogen, oxygen and ash are determined.

Biodegradable - A substance that can be broken down by microorganisms.

Burner, Refuse - A device for centre or on-site burning of refuse. It is very simple in construction and all the factors of combustion are not controlled.

Burner, Secondary - A burner installed in the secondary combustion chamber to maintain a specified minimum temperature and complete combustion of incompletely burnt gases.

Burning Rate - The quantity of solid waste incinerated (expressed as kg/m sq h) or the amount of heat released (expressed as cal/m sq h) during incineration.

Calorific Value - Number of heat units obtained by complete combustion of unit mass of a fuel.

Clinker - Hard, sintered or fused pieces of residue formed in a fire by agglomeration of ash, metals, glass and ceramics.

Combustion Air, Excess - Air that is supplied in excess of theoretical air. It is normally expressed as a percentage of theoretical air.

Combustion Air, Primary - Air that is added to combustion system at the point where fuel is first oxidized.

Combustion Air, Secondary - Air introduced above or beyond a fuel bed by natural, induced or forced draft. It is generally referred to as over fire, air, if supplied above the fuel bed through the side walls or the bridge wall of primary chamber.

Combustion Air, Theoretical - The amount of air required to completely burn the waste. The amount is calculated from the chemical composition of the waste and is also known as stoichiornetric air.

Damper - A manually or mechanically controlled valve or plate fixed in a breeching, duct or stack that is used to regulate a draft or rate of flow of air or other gases.

Electrostatic Precipitator - A device for collecting particulates by placing an electric charge on them and then attracting them to a collecting electrode.

Emissions - The sum of total substances discharged into air from a stack, vent or any other discrete source. It is generally applicable to harmful and injurious substances.

Emission Standard - A rule or measurement established to regulate or control the amount of a given pollutant which may be discharged into the atmosphere from the source.

Facultative - Able to live and grow with or without free oxygen.

Flue - A passage designed to carry combustion gasses and entrained particles.

Fluidized Bed Technique - A combustion process in which heat is transferred from finely divided particles such as sand to combustible materials when kept in a fluidized state in a combustion chamber.

Fly Ash - The finely divided particles of ash entrained in flue gases arising from the combustion of fuel. The particles of ash may contain incompletely burned fuel. The term has been applied predominantly to gas-borne ash from boilers with spreader stoker, underfeed stoker, and pul-varized fuel (coal) firing. The particles fall to the ground close to the point of release.

Garbage - Waste food material originally intended for or associated with food for human consumption.

Garchey System - A patented system' in which refuse is first stored in a water filled flushing device under a sink from where it is conveyed through tubes to a central holding tank.

Grate - A device which supports solid fuel or solid waste during drying, ignition and combustion and the openings in it permit air to pass through it.

Heat Release Rate - The amount of heat released during complete combustion. Generally it is expressed as kcal/m (of internal volume of furnace) h.

Heat Value, High - The amount of heat, expressed in kilocalories liberated when a kilogram of solid waste is completely burnt and the pro ducts of combustion are cooled to initial temperature of solid waste as in a calorimeter.

Heat Value, Low - The high heat value minus the latent heat of vaporization of water formed by burning the hydrogen in fuel.

Ignition Temperature - Lowest temperature at which a fuel can be burnt by a self-sustaining combustion reaction.

Leachate - Liquid that has travelled through solid waste or other medium and has extracted, dissolved or suspended material from it.

Odour Threshold - The lowest concentration of a substance in air at which its odour is perceptible.

Pathogen - An organism capable of producing disease.

Pollution - Presence in the environment of some substances of such type and quantity that the quality of the environment is impaired or rendered offensive to life.

Putrefaction - Microbial decomposition of organic matter accompanied by odours.

Recycling - The process by which waste materials are transformed into new products in such a manner that the original products lose their identity.

Refuse - It includes all kinds of wastes in solid state, excepting excreta, coming from residential, commercial and industrial areas.

Reuse - The reintroduction of a commodity into the economic stream without any change.

Salvaging - Controlled removal of waste material for utilization.

Satellite Vehicle - A small vehicle which discharges its contents into an

accompanying large vehicle.

Slag - A substance formed by chemical action- and fusion at furnace operating temperatures.

Street Refuse - Refuse collected from streets when they are cleaned either manually or mechanically.

Transfer Station - A site at which solid waste is transferred from one set of vehicles to another directly or after compaction.

Vector, Disease - A carrier capable of transmitting a pathogen from one vector to another.

ANNEXURE-II

Table:-1 Waste Generation Rates and Composition and Characterization of MSW in 59 Cities.

SN	Name of City	Population (As per 2001 census)	Area (Sq. km)	Waste Quantity (TPD)	Waste Generation Rate (kg/c/day)	Compostables (%)	Recyclables (%)	C/N Ratio	HCV* (Kcal/Kg)	Moisture (%)
Cities having population less than 1 lakh										
1	Kavaratti	10,119	4	3	0.30	46.01	27.20	18.04	2242	25
2	Gangtok	29,354	15	13	0.44	46.52	16.48	25.61	1234	44
3	Itanagar	35,022	22	12	0.34	52.02	20.57	17.68	3414	50
4	Daman	35,770	7	15	0.42	29.60	22.02	22.34	2588	53
5	Silvassa	50,463	17	16	0.32	71.67	13.97	35.24	1281	42
6	Panjim	59,066	69	32	0.54	61.75	17.44	23.77	2211	47
7	Kohima	77,030	30	13	0.17	57.48	22.67	30.87	2844	65
8	Port Blair	99,984	18	76	0.76	48.25	27.66	35.58	1474	63
Cities having population between 1-5 lakhs										
9	Shillong	1 ,32,867	10	45	0.34	62.54	17.27	28.86	2736	63
10	Simla	1,42,555	20	39	0.27	43.02	36.64	23.76	2572	60
11	Agartala	1,89,998	63	77	0.40	58.57	13.68	30.02	2427	60
12	Gandhinagar	1 ,95,985	57	44	0.22	34.30	13.20	36.05	698	24
13	Dhanbad	1,99,258	24	77	0.39	46.93	16.16	18.22	591	50
14	Pondicherry	2,20,865	19	130	0.59	49.96	24,29	36.86	1846	54
15	Imphal	2,21,492	34	43	0.19	60.00	18,51	22.34	3766	40
16	Aizwal	2,28,280	117	57	0.25	54.24	20.97	27.45	3766	43
17	Jammu	3,69,959	102	215	0.58	51.51	21.08	26.79	1782	40
18	Dehradun	4,26,674	67	131	0.31	51.37	19.58	25.90	2445	60
19	Asansol	4,75,439	127	207	0.44	50.33	14.21	14.08	1156	54

SN	Name of City	Population (As per 2001 census)	Area (Sq. km)	Waste Quantity (TPD)	Waste Generation Rate (kg/c/day)	Compostables (%)	Recyclables (%)	C/N Ratio	HCV* (Kcal/Kg)	Moisture (%)
Cities having population between 5-10 lakhs										
20	Kochi	5,95,575	98	400	0.67	57.34	19.36	18.22	591	50
21	Raipur	6,05,747	56	184	0.30	51.40	16.31	23.50	1273	29
22	Bhubanesvar	6,48,032	135	234	0.36	49.81	12.69	20.57	742	59
23	Tiruvanantapuram	7,44,983	142	171	0.23	72.96	14.36	35.19	2378	60
24	Chandigarh	8,08,515	114	326	0.40	57.18	10.91	20.52	1408	64
25	Guwahati	8,09,895	218	166	0.20	53.69	23.28	17.71	1519	61
26	Ranchi	8,47,093	224	208	0.25	51.49	9.86	20.23	1060	49
27	Vijaywada	8,51,282	58	374	0.44	59.43	17.40	33.90	1910	46
28	Srinagar	8,98,440	341	428	0.48	61.77	17.76	22.46	1264	61
29	Madurai	9,28,869	52	275	0.30	55.32	17.25	32.69	1813	46
30	Coimbatore	9,30,882	107	530	0.57	50.06	15.52	45.83	2391	54
31	Jabalpur	9,32,484	134	216	0.23	48.07	16.61	28.22	2051	35
32	Amritsar	9,66,862	77	438	0.45	65.02	13.94	30.69	1836	61
33	Rajkot	9,67,476	105	207	0.21	41.50	11.20	52.56	687	17
34	Allahabad	9,75,393	71	509	0.52	35.49	19.22	19.00	1180	18
35	Visakhapattanam	9,82,904	110	584	0.59	45.96	24.20	41.70	1602	53
Cities having population between 10-20 lakhs										
36	Faridabad	10,55,938	216	448	0.42	42.06	23.31	18.58	1319	34
37	Meerut	10,68,772	142	490	0.46	54.54	10.96	19.24	1089	32
38	Nashik	10,77,236	269	200	0.19	39.52	25.11	37.20	2762	62
39	Varanasi	10,91,918	80	425	0.39	45.18	17.23	19.40	804	44

SN	Name of City	Population (As per 2001 census)	Area (Sq. km)	Waste Quantity (TPD)	Waste Generation Rate (kg/c/day)	Compostables (%)	Recyclables (%)	C/N Ratio	HCV* (Kcal/Kg)	Moisture (%)
40	Jamshedpur	11,04,713	64	338	0.31	43.36	15.69	19.69	1009	48
41	Agra	12,75,135	140	654	0.51	46.38	15.79	21.56	520	28
42	Vadodara	13,06,227	240	357	0.27	47.43	14.50	40.34	1781	25
43	Patna	13,66,444	107	511	0.37	51.96	12.57	18.62	819	36
44	Ludhiana	13,98,467	159	735	0.53	49.80	19.32	52.17	2559	65
45	Bhopal	14,37,354	286	574	0.40	52.44	22.33	21.58	1421	43
46	Indore	14,74,968	130	557	0.38	48.97	12.57	29.30	1437	31
Cities having population greater than 20 lakhs										
47	Nagpur	20,52,066	218	504	0.25	47.41	15.53	26.37	2632	41
48	Lucknow	21,85,927	310	475	0.22	47.41	15.53	21.41	1557	60
49	Jaipur	23,22,575	518	904	0.39	45.50	12.10	43.29	834	21
50	Surat	24,33,835	112	1000	0.41	56.87	11.21	42.16	990	51
51	Pune	25,38,473	244	1175	0.46	62.44	16.66	35.54	2531	63
52	Kanpur	25,51,337	267	1100	0.43	47.52	11.93	27.64	1571	46
53	Ahmedabad	35,20,085	191	1302	0.37	40.81	11.65	29.64	1180	32
54	Hyderabad	38,43,585	169	2187	0.57	54.20	21.60	25.90	1969	46
55	Banglore	43,01,326	226	1669	0.39	51.84	22.43	35.12	2386	55
56	Chennai	43,43,645	174	3036	0.62	51.34	16.34	29.25	2594	47
57	Kolkata	45,72,876	187	2653	0.58	50.56	11.48	31.81	1201	46
58	Delhi	1 ,03,06,452	1483	5922	0.57	54.42	15.52	34.87	1802	49
59	Greater Mumbai	1,19,78,450	437	5320	0.45	62.44	16.66	39.04	1786	54

*** HCV on dry weight basis**